AMERICAN HEART JOURNAL

For the Study of the CIRCULATION

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PUBLISHED MONTHLY

Under the Editorial Direction of

THE AMERICAN HEART ASSOCIATION

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VOLUME 23

JANUARY—JUNE, 1942

ST. LOUIS

THE C. V. MOSBY COMPANY

1942

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Printed in the
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Press of
The C. V. Mosby Company
St. Louis

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The American Heart Association

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Published by THE C. V. MOSBY COMPANY, 3525 Pine Blvd., St. Louis, U.S.A.
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Vol. 23, No. 1, January, 1942. The American Heart Journal is published monthly by the C. V. Mosby Company, 3523 Pine Blvd., St. Louis, Mo. Subscription Price: United States, its Possessions, Pan-American Countries, $10.00; Canada, $11.50 (Canadian Currency); Foreign, $11.00. Entered as Second-Class Matter at Post Office at St. Louis, Mo., under Act of March 3, 1879. Printed in the U. S. A.

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The American Heart Journal

VOL. 23 JANUARY, 1942 NO. 1

Original Communications

SOME IMMEDIATE CAUSES OF CARDIAC INFARCTION

ERNST P. BOAS, M.D.
NEW YORK, N. Y.

IS CARDIAC infarction a fortuitous occurrence, or are there specific, recognizable circumstances that precede the cardiac damage? This is an old problem, and one that is still giving rise to much discussion. Some years ago, Fitzhugh and Hamilton[1] collected a series of cases of coronary thrombosis in which it appeared that the attacks were brought on by some unusual event. In the intervening years we have learned a good deal about coronary artery disease. We know that cardiac infarction can take place without coronary thrombosis.[2] We understand something about the role played by hemorrhages into the coronary arterial wall in causing closure of the coronary lumen. We have learned to recognize the so-called premonitory symptoms of cardiac infarction and realize that changes in the coronary circulation which eventually lead to complete arterial occlusion may develop over a period of days, possibly weeks.

Much of the confusion that has arisen is due to the lack of differentiation between attacks of angina pectoris, coronary occlusion, and coronary insufficiency. By angina pectoris we understand the particular type of heart pain which is usually induced by exertion or excitement, is of short duration, and is not followed by permanent myocardial damage. Yet it is now accepted that every attack of angina pectoris is due to transient coronary insufficiency, and that an electrocardiogram taken during an attack of pain may show changes indicative of heart muscle damage; these changes disappear promptly after the attack. We are accustomed to associate the concept of coronary occlusion with dramatic and severe symptoms, namely, shock, a fall in blood pressure, fever, and heart failure, with progressive electrocardiographic changes. As a matter of fact, it is often difficult to ascertain whether an attack of heart pain represents simple angina or coronary occlusion.

Received for publication May 28, 1941.

This has been brought out very forcibly by the recent work of Blumgart and Schlesinger.[3] In painstaking autopsy studies, using a special method developed by Schlesinger, they were able to show that in all cases in which the subject had suffered from simple angina pectoris, without complicating hypertension or valvular disease, and with no symptoms suggesting cardiac infarction, there were occlusions of several coronary arteries, but there was no significant scarring of the heart muscle. In these cases the development of the arterial disease was so slow that there was time for the establishment of an adequate collateral circulation, so that, when one of the coronary arteries was occluded, infarction of the myocardium did not take place. Blumgart pointed out that, when patients who were previously well suddenly develop angina pectoris, particularly at rest, one must suspect coronary narrowing or occlusion, even if none of the signs of cardiac infarction appear.

Very commonly we encounter a patient who tells us that he has had typical angina pectoris for many months and that he has never been incapacitated by any severe attack that compelled him to go to bed. Yet, if one says to such a patient, "Do you remember the very first time you had this pain, and did the initial attack differ in any way from the subsequent ones?" he is very likely to answer something like this (I cite two cases from my files): "Oh, yes, I remember that I was at a New Year's party and drank too much, ate too much, and danced a good deal. While dancing, I suddenly experienced substernal pain, broke out into a sweat, and had to sit down, but the symptoms disappeared in about fifteen minutes. I then went home and slept it off and returned to work the next day. Ever since, walking a few blocks has provoked similar symptoms."

Another man will tell you that the first attack occurred while he was shoveling snow on a cold winter day, and that the pain compelled him to stop, go into the house, and rest, but that it did not compel him to be away from his work.

Many, but not all, of these patients, when examined subsequently, show electrocardiographic changes which are indicative of myocardial damage.

It is my conviction that such patients, who are ordinarily regarded as having simple angina pectoris, have at the outset experienced organic damage to one of their coronary arteries, leading either to permanent narrowing or occlusion of the vessel.

Blumgart and his associates called attention to persons who have prolonged attacks of classical anginal pain which are not followed by fever or other evidence of infarction, and show no infarction post mortem. Such cases they ascribe to coronary failure which causes a reversible myocardial ischemia. They point out that such attacks are occasionally coincident with increased demands on the heart and that

they may be provoked by a paroxysmal abnormal rhythm, emotional upsets, or exertion. At times they may follow sudden insufficiency of the coronary flow secondary to shock or hemorrhage. Fresh infarcts may occur without fresh coronary occlusion when the coronary failure is prolonged to a point where myocardial necrosis takes place.

The demonstration of the frequency with which coronary occlusion and consequent cardiac infarction result from hemorrhage into the arterial wall has thrown new light on some forms of coronary occlusion.[4] These pathologic studies offer a possible explanation for certain cases of traumatic cardiac infarction and for the sudden onset of symptoms of angina pectoris. They also could account for gradual coronary occlusions that may take days to become complete. There may be a gradual growth of the hematoma in the arterial wall, or gradual formation of an intra-arterial thrombus over the site of the hemorrhage into the arterial wall.[5]

I wish to present a series of cases of cardiac infarction in which the sequence of events suggested a direct connection between the cardiac infarction and some concrete, antecedent happening. These are not rare or isolated cases. They were culled from many that I have encountered in my practice. Indeed, these relationships occur with such frequency that I, for one, have become convinced of their causal connection.

NONPENETRATING CHEST INJURIES

I do not propose to dwell long on nonpenetrating injuries of the chest that produce myocardial damage. The mechanism of this is now generally understood, and I have summarized the evidence in an earlier paper.[9a] Since that time, Warburg[6] and Barber[7] have published additional cases. The following is still another case.

CASE 1.—A man, aged 40, while driving his car, collided head on with a truck. He became momentarily unconscious. When he awoke, he was lying over the steering wheel, which had been bent forward so that it rested against the windshield. He clambered out of the car, collapsed, and felt a tightness across the anterior part of the chest. He was driven to a doctor's office. No bruises were found on his chest, and no ribs were broken. He was then driven to his office, about 6 miles, and then home, another 7 miles. He stayed in bed two weeks. During this period he was constantly short of breath and felt a tightness across the anterior part of the chest. He had no fever. He tried to return to work after a fortnight, but was unable to do so because of aggravation of the pain in his chest, and dyspnea on slight effort and on talking to customers. Examination by many physicians revealed no cause for his symptoms until nine months after the accident, when an electrocardiogram was taken and showed bundle branch block. Physical examination was essentially negative, except for some sclerosis of the radial and temporal arteries. The eye grounds were normal. The heart was not enlarged. The heart sounds were of good quality, and there were no murmurs. The blood pressure was 110/60.

This type of cardiac damage, caused by direct blows to the chest wall, may be due to contusion of the heart, with hemorrhage into the myo-

cardium, or to injury of one of the coronary arteries. Violent jars to the body may have a similar effect. The heart is suspended from the aorta, and hangs free in the mediastinum. A sudden, forcible fall may induce a vigorous pendulum-like movement of the heart, and traumatize it severely. I can cite several cases that seem to fall into this category.

CASE 2.—A hotel manager, aged 45, had been under my care since 1932. He had never had any serious illness, nor any symptoms or signs referable to any abnormality of the heart. While on his vacation in the fall of 1939 he played baseball, and, when batting, missed the ball, stumbled, and fell on his buttocks. At first he thought he was unhurt, but a few minutes later began to experience substernal oppression and difficulty in breathing, and soon broke out in a cold sweat. The pain persisted for several hours, until he received an injection of morphine. Precordial oppression lasted all night. I saw him two days later. The heart was somewhat enlarged; the heart sounds were very faint; and the rate was rapid. The blood pressure was 84, systolic. The following day a pericardial friction rub was heard. Fever persisted for a week. The electrocardiogram revealed the classical picture of infarction of the posterior aspect of the left ventricle. Two weeks after the onset of symptoms, right-sided hemiplegia and aphasia occurred suddenly. The patient has continued to have a very poor cardiac reserve, with a persistent hemiplegia and aphasia.

A similar case has been reported by Kienle.[8]

EFFORT

The interpretation of the mechanism of cardiac infarction which occurs during or after effort is of the greatest practical significance. Those who have held that effort is not directly concerned with the induction of cardiac infarction have relied largely on statistical evidence. They have pointed out the fact that, in many cases, cardiac infarction occurs while the patient is at rest or asleep, and that, when effort and cardiac infarction occur simultaneously, the relationship is coincidental, not causal. To me this is very specious reasoning. We might as well say that, because only rarely can we demonstrate a direct connection between local irritation and cancer, chimney sweeps' cancer of the scrotum has nothing to do with their occupation. As Bean recently pointed out, the fact that most motor accidents do not occur at speeds of 70 miles an hour does not prove that such speeds may not be concerned in some motor accidents.

With the growing accumulation of cases in which there seems to be such a direct connection between effort and the onset of cardiac symptoms, and with our clearer understanding of the physiologic mechanisms, particularly that of cardiac infarction without coronary thrombosis, we must accept this relationship as a very definite one.[9] Indeed, it is my conviction that the more carefully we delve into the history of patients who have had cardiac infarction, the more often will we find definite precipitating causes. Clinicians of a previous generation recognized that effort might precipitate a fatal attack in patients with coronary

disease. Thus Osler[10] writes: "Hurrying to catch a train has often been the exciting cause of a fatal attack in the subjects of angina. The muscular and mental excitement of coitus is particularly dangerous, and has in many instances caused death."

I propose to present some cases that exhibit this relationship.

In 1906, James Mackenzie recorded a classical example.[11]

A builder, aged 48, for some months had had slight substernal pain on walking uphill. One day while overseeing his men he felt cold. To warm up he helped them dig for fifteen minutes, and then ran up and down the stairs of some partly built houses. On his way home he experienced substernal pain of increasing severity. The pain became very intense, radiated down the left arm, and lasted hours, until opium was given. It recurred the following morning, and was accompanied by a drenching sweat. After three weeks' rest he made a good recovery.

The following cases are from my files.

CASE 3.—A man, aged 62, a tailor, had always been well and had had no symptoms referable to his heart until Oct. 6, 1940, when he helped his son push a stalled automobile. While pushing the car he broke out into a cold sweat, became dizzy, and experienced severe squeezing pain across the mid-chest which lasted twenty minutes. He had to sit down immediately, and rested the remainder of the day. That night he was awakened by a similar pain which lasted an hour and a half. The next day, however, he returned to work, and, from time to time, experienced mild substernal pain for which he would rest for a short time. On October 11 he again had a nocturnal attack which lasted two hours, but he returned to work the next day. On this day, for the first time, he noted substernal pain on walking two blocks, compelling him to rest. This symptom of angina on effort persisted until I saw him on October 26. Physical examination revealed few abnormalities. The heart was not enlarged. The first heart sound was of good quality. The aortic second sound was accentuated. There was a systolic murmur at the apex. The blood pressure was 150/80. The electrocardiogram showed low voltage and abnormal R-T segments in Leads I, II, and IV.

This case illustrates a number of significant features which are frequently encountered. Anginal symptoms came on suddenly, and for the first time, during severe effort. This was followed twelve hours and, again, five days later by prolonged, spontaneous attacks of anginal pain. After the second spontaneous attack, classical angina on effort set in and continued. Throughout this whole period, during which cardiac infarction occurred, the patient continued up and about and at work.

CASE 4.—A truck driver, aged 37, had been perfectly well and had worked hard without any symptoms until Nov. 9, 1940. He was loading some heavy cases on his truck; four cases had already been loaded, and he was working on the fifth case, assisted by three other men. This case weighed about 1,100 lbs. He used a case hook and lifted it with two hands, using all his strength to get it on a hand truck. While engaged in this maneuver, he experienced a pressing pain across the anterior part of the chest. Although the pain continued, he helped finish loading the case onto his truck and helped with one more case. However, he did not exert

himself much, because, as he said, "he knew he was hurt." He drove his truck one and a half blocks to get some papers signed, and then drove three blocks to the ferry. While on the ferry he felt so weak that he lay down on his seat. He was dizzy and his arms and shoulders felt numb. He then drove six blocks to the place where he had to deliver his goods. He walked into the office and felt as though he were going to die. He could get no air. Pain in the anterior part of the chest and down to the fingers of both arms continued. He got some men to unload his truck for him. He then drove his truck back to New York, called his boss, and told him that he could not continue his work. In walking to the subway he had to stop every few steps, but finally got home at about 11:45 A.M. Soon thereafter he was taken to a hospital. He was febrile for six days. The electrocardiogram was typical of acute infarction of the anterior aspect of the left ventricle.

With increasing frequency we are faced by the question whether a particular accident or effort during work is able to cause cardiac infarction, and whether the workingman is entitled to compensation for his disability. Recognition of the fact that effort can induce cardiac infarction makes it necessary to evaluate each case on its merits. To establish a causal connection between the effort and the cardiac accident we must assure ourselves first that the history is honest and accurate. Cardiac symptoms must accompany or immediately follow the event to which the cardiac injury is ascribed. If the symptoms are immediately disabling, the causal connection is clear. If a lapse of days occurs between the accident and complete disablement, there must be a continuity of symptoms dating from the event. It is conceivable that an intra-arterial coronary hemorrhage might give rise to no symptoms for several days, that is, until marked obstruction of the artery had taken place. The possibility of the occurrence of such a train of events is not yet strong enough to warrant its presentation as fact in a court of law. One other point requires consideration. A particular physical strain may be the cause of cardiac infarction, and yet, in the legal sense, not entitle the workingman to compensation. In many states the law requires that disability, to be compensable, must result from an accident or an unusual effort. Thus, if a man, year in and year out, carries on a laborious occupation and during the course of this usual occupation sustains a cardiac infarction, the cardiac accident may have been caused by the stress of his work, but it is not compensable. But if some exceptional circumstance immediately preceded the cardiac symptoms, i.e., if he had to lift some unusually heavy weight, or if he slipped while lifting, the *unusual* strain would be regarded as the cause of the cardiac disability, and therefore compensable.

We are all acquainted with patients who had had frank coronary thrombosis but continued at work because the condition was not recognized. Instances of sudden death in which at autopsy a fresh infarct is found belong in this category. Not so rarely, such patients have no antecedent history of the classical symptoms of coronary thrombosis.

They may have had minor distress in the chest, or a transient indisposition some days previously, but continued at their work, unaware of their serious illness. Then they suddenly drop dead while at their usual occupation. Many such cases were collected by Hallermann[12] in his monograph on sudden death in coronary disease. In such cases, of course, although the work is the final precipitating cause of death, it is not responsible for the cardiac damage.

EMOTION

The effect of joy, sorrow, fear, and other emotional disturbances on the heart is recognized by laymen everywhere. This finds expression in folklore and in our daily speech. We die broken-hearted. Our heart stands still with fear. Travelers and anthropologists have recorded many stories of natives who lie down and die after having broken some tribal taboo, or if they believe that they have been enchanted. Such cases have been described particularly among the Maoris and New Zealanders.[13] Death may occur in a few days or weeks. Such cases to us are incomprehensible, and they lack clinical and pathologic verification, but sudden death after emotional trauma is a common occurrence.

Klinkenberg[14] cited a case of death from emotional shock in which autopsy revealed no cause of death. More numerous, and more comprehensible, are reports of persons with heart disease who died suddenly as a result of great excitement. King Philip V died suddenly when told that the Spaniards had been defeated. At autopsy a rupture of the heart was found.[15] Martin and Villanova[16] described the case of a man who died suddenly after having been held up and robbed. At autopsy, advanced coronary artery disease was found. The case best known to physicians is that of John Hunter, who had suffered from angina pectoris for twenty years, and was accustomed to say that his "life was in the hands of any rascal who chose to annoy and tease him." As a matter of fact, one day in a medical board meeting one of his colleagues flatly contradicted him. Hunter immediately ceased speaking, struggled to suppress the tumult of his passion, hurried to an adjoining room, and fell over lifeless.

CASE 5.—One of my patients, a man, aged 44, had had coronary artery thrombosis at the age of 39. Thereafter he had typical angina pectoris on walking a few blocks, and, because of the easily precipitated pain, was unable to work. He was observed for three years, during which time there was no significant change in his symptoms or in the physical signs. The heart was not enlarged; the first heart sound was a bit dull; and the blood pressure was 110/85. The first electrocardiogram, taken six months after the cardiac infarction, showed a diphasic T wave in Lead I. The last electrocardiogram, taken three years after the initial attack, was normal. Two years later he got up at 2 A.M. to take his 75-year-old mother, who had an infection of the left leg, to the hospital. While he was standing at his mother's bedside in the hospital, giving the history to the intern, he suddenly collapsed and died.

The mechanism of such deaths remains a matter for speculation. In persons with antecedent coronary disease the course of events is more easily understood than in those with previously healthy hearts. It is quite conceivable that reflexes released by emotional trauma, or possibly a sudden outpouring of adrenalin, may initiate ventricular fibrillation, which is quickly followed by death. In other cases the associated vasomotor changes may lead to transient myocardial anoxemia, as a result of the underlying coronary artery sclerosis, and this, in turn, may induce ventricular fibrillation. Mainzer and Krause[17] have described changes in the electrocardiogram brought about by fear. Wilson and Johnston[18] have brought evidence to show that myocardial ischemia can result from spasm of the coronary arteries, without increase in the work of the heart.

If we accept relative myocardial ischemia, that is, a disproportion between the blood flow and the physiologic needs of the heart muscle, as a cause of cardiac infarction, we should expect that grave emotional disturbance might act in a manner similar to effort in producing irreversible damage to the heart muscle. I have observed many cases in which cardiac infarction immediately followed emotional trauma.

CASE 6.—A very high-strung man, aged 34, who had been quite well, was visiting in Montreal. In the evening, while walking, he felt very uncomfortable because of an overdistended bladder. He went into an alley to empty his bladder, and was arrested for committing a nuisance. He was locked up overnight, and was not permitted to telephone to a lawyer or to friends. He became very much excited, and while in his cell developed substernal pain which lasted several hours. The next day he was released, and, on reaching home, developed very severe substernal pain, followed by shock and the classical symptoms of cardiac infarction. An electrocardiogram revealed the pattern of infarction of the posterior aspect of the left ventricle.

CASE 7.—This patient was first seen in 1931, at the age of 48. For two months he had been having pain in the right scapula that radiated to the sternum; the pain was induced by walking, and compelled him to stop after about one block. Examination revealed a heart of normal size and configuration, moderate dilatation of the ascending aorta, good heart sounds, and systolic murmurs at the apex and aortic areas. The blood pressure was 120/80. The electrocardiogram showed Q waves in the three limb leads, and diphasic T waves in Leads II and III. The anginal symptoms subsided after a few months, and he was then perfectly well until December, 1938, when he was awakened with a start one night by the crash of an automobile collision. He rushed to the window and saw one of the cars in flames, and recognized it as his son's car. He promptly fainted. When he came to in a few minutes, he was in a cold sweat, and felt slight pressing pain between the scapulae. He stayed in bed one day. He developed no fever. Then for a number of days he noted that walking a few blocks would induce interscapular pain and pain in the right elbow. He also felt very weak. Examination three weeks after the accident revealed moist râles at the bases of both lungs, heart sounds of poor quality, and a heart rate of 100, with a suggestion of gallop rhythm. The liver was felt 1 fingerbreadth below the costal margin. The blood pressure was 78/60. The electrocardiogram showed, in addition to the changes noted in 1931, slurring of the QRS, a diphasic T wave in Lead I, and a small Q wave and a negative T wave in Lead IV.

ALLERGY

The relationship of allergy to cardiac lesions is controversial. We need not follow Werley,[19] who finds food allergy in most patients with angina pectoris. However, he describes one patient who developed anginal pain during an attack of angioneurotic edema; the T wave in Lead I was isoelectric during the attack and returned to normal one week later. Cardiac damage has often been described in experimental animals who were subjected to anaphylactic shock. Thus, Ewert and Kallos[20] produced asthmatic attacks in sensitized guinea pigs by having them inhale homologous antigens. With these asthmatic seizures, electrocardiographic changes were observed. The T wave became negative in all leads, and there were disturbances of rhythm and conduction. In the most severe cases the electrocardiograms resembled those of cardiac infarction. In animals that recovered, the electrocardiograms again became normal. In those that died, histologic studies of the heart muscle showed nothing abnormal. Harkavy[21] collected a number of unequivocal cases of coronary disease, with reversible electrocardiographic changes which occurred in young patients during attacks of bronchial asthma. Von Eiselsberg[22] described patients with angina pectoris who were sensitive to certain foods and were cured of their symptoms by elimination diets.

I know of one case of cardiac infarction which occurred in a man, aged 46, during an attack of serum sickness caused by an injection of tetanus antitoxin. A similar case has been published.[23] A man cut his finger and received tetanus antitoxin. A week later a rash appeared, and he had an attack of syncope and precordial pain. A week later a second attack was followed by death. Autopsy revealed coronary sclerosis and recent myocardial infarction.

CASE 8.—A man, aged 34, was first seen in 1932. He had had typical symptoms of angina pectoris for six months. He smoked ten cigars a day. During the following two years he stopped smoking on a number of occasions for months at a time. Thereupon his angina would disappear, to recur when he resumed smoking. Physical examination and electrocardiograms never showed anything abnormal. In May, 1934, he had again been smoking. He had no anginal symptoms, but his right great toe had become intensely painful, so that he had been unable to sleep for several nights. The right toe was cold and blue. There was a good dorsalis pedis pulse in the right foot. After failure of symptomatic treatment, typhoid vaccine was given intravenously, with immediate relief from pain. After a few treatments the condition cleared up completely. He was then well and active until October, 1936. He had stopped smoking for seven months, but had then resumed. He complained of severe pain in the toes of the left foot, and attacks of slight substernal pain. Physical examination was completely negative. He was given an intravenous injection of typhoid vaccine. One hour after the injection he had a chill, followed by a fever. Six hours later he experienced very severe pain across the anterior part of the chest which was not relieved by morphine. The following day his blood pressure had dropped to 96/48; the heart sounds were of fair quality; the heart

rate was 100; and the electrocardiogram was unchanged. He was admitted to the hospital, where he ran a typical course of cardiac infarction. He made a good recovery and two years later was well and asymptomatic.

In this case it is a question whether the typhoid injection induced the cardiac infarction through the nonspecific effect of the chill and fever, or whether the typhoid injections two years previously had sensitized him, so that it was in the nature of an allergic reaction.

Cardiac death after intravenous typhoid injection has been reported.[24] A man who had had no symptoms referable to the heart received typhoid vaccine for a toxic erythema. Three hours after the injection, at the height of the febrile reaction, the patient collapsed and died within an hour. At autopsy an old healed infarct was found in the anterior wall of the left ventricle, and a fresh thrombus, without a fresh infarct, was discovered proximal to the old lesion.

Cases have been described of persons who developed urticaria and anginal pain, with definite, but transient, electrocardiographic changes, after the ingestion of acetylsalicylic acid.[25] Attacks could be produced at will by taking the drug. These patients had preexisting coronary disease. Shookoff and Lieberman[26] observed a man, aged 63, with asthma and hay fever due to ragweed. One August he developed severe, frequent, anginal attacks at rest, in the absence of hay fever and asthma. The attacks were controlled only when the patient was placed in a room, the air of which had been freed of pollen by filters.

CASE 9.—A man, aged 53, had had hay fever for three years. For six months he had been receiving injections, in large doses, for the treatment of hay fever. Invariably, two or three hours after each injection, he experienced substernal cramps which lasted one to two hours. The dosage of the injections was reduced, and, although the attacks persisted, they were of less intensity. He complained of similar pain when he lifted heavy things, when he climbed stairs, and on excitement. General physical examination was negative. Fluoroscopic examination revealed a heart of normal size and configuration. The heart sounds were of good quality. There were no murmurs. The blood pressure was 140/90. The electrocardiogram was normal.

The evidence clearly suggests that in certain instances allergic reactions may give rise to attacks of angina pectoris or of cardiac infarction.

COLD

It has been known for years[27] that drinking ice water may cause an immediate inversion of the T waves in Leads II and III. Luten[28] described two cases of cardiac infarction which occurred immediately after drinking ice water. In such instances the diaphragmatic portion of the heart is chilled directly by the ice water in the stomach. Chilling of the body commonly induces anginal seizures. It is commonplace for a patient with coronary artery disease to experience an anginal seizure as

soon as he steps out of his house on a cold winter day, or on going to bed between cold sheets. The mechanism here is probably a reflex one. Moderate exertion in cold weather often immediately precedes cardiac infarction. In these cases two factors are simultaneously operative, namely, reflex coronary spasm and effort. A number of statistical studies have shown that cardiac infarction occurs more frequently during the cold than during the warm months of the year.[29] I have had a number of patients whose symptoms of cardiac infarction commenced while they were trudging through deep snow on a cold winter day. Every winter I see a number of patients who experienced the initial symptoms of cardiac infarction while shoveling snow.

On March 2, 1941, the day after a severe snow storm, the New York *Times* reported eight deaths caused by the storm in New Jersey. Three men died of heart attacks while shoveling snow. One man, aged 73, died while fighting his way through the snow, and another man died of a heart attack while helping a stalled motorist out of a drift.

INFECTIOUS DISEASE

I have observed not a few patients who had an intercurrent infection which appeared to precipitate coronary thrombosis or cardiac infarction. Often these infections are relatively mild, i.e., so-called grippe, or mild bronchitis. Huchard[30] wrote that deaths from angina pectoris are very frequent during grippe epidemics.

CASE 10.—A man, aged 57, had had a peptic ulcer for thirteen years, with intermittent symptoms. The ulcer symptoms had been active during the second half of 1939. During the same period he complained of burning pain in the left upper extremity. Several weeks before I saw him he caught cold, and complained of a cough, chilliness, and a mild heaviness in the upper mid-chest. He was in bed for two days. He left the bed on the third day and went to his store. He felt the same heaviness in the upper mid-chest, which soon turned into a pain severe enough to necessitate a hypodermic injection. He returned home and was in bed for six weeks. He was examined seven weeks after the onset. General examination was negative. Fluoroscopic examination revealed a heart of normal size and configuration. The heart sounds were dull. There were no murmurs. The electrocardiogram showed left axis deviation and a diphasic T wave in Lead IV.

OPERATION AND HEMORRHAGE

It is unnecessary to dwell on surgical operations as an immediate cause of cardiac infarction. Today this sequence is recognized by most cardiologists.[31] Shock or hemorrhage may reduce coronary flow to a point at which irreversible myocardial damage occurs. When the cardiac infarction occurs several days after the operation, alterations in coagulability of the blood may play a role. I have seen a number of patients whose cardiac infarction followed extraction of a tooth.

CASE 11.—A man, aged 55, was first seen in April, 1938. He had had an enlarged heart for years, but no cardiac symptoms until a year previously, when he began

experiencing typical angina pectoris, at first only on exertion, but subsequently, spontaneously at night. General physical examination was negative except for moderate pallor. Fluoroscopic examination revealed much enlargement of the left ventricle and moderate enlargement of the left auricle. The secondary branches of the pulmonary arteries were dilated. The first heart sound was of good quality; the second sound was reduplicated. At the apex there was a loud, musical, systolic murmur which was transmitted to the axilla. The blood pressure was 100/60. The electrocardiogram showed rather low T waves in the three limb leads, and a deep Q wave, with an upright T wave, in Lead IV. He was seen again in January, 1939. He had become very pale; the hemoglobin was 38 per cent. His stool gave a positive guaiac test. General physical examination was still negative. Repeated roentgenograms of the colon were negative, and, under iron therapy, the hemoglobin rose to 70 per cent. In June, 1939, he had a severe intestinal hemorrhage, with collapse. A few hours after this he was seized with severe substernal pain which lasted hours and required morphine for relief. The electrocardiogram revealed the typical pattern of posterior infarction. The heart sounds were poor, and he was febrile for ten days. When he recovered from his cardiac infarction, he had another roentgenogram of his colon, and a carcinoma of the ascending colon was finally discovered. He was operated on and made a good recovery.

A variety of other factors may precipitate cardiac infarction. Probably the most common is the eating of too large a meal. Cardiac infarction occurs frequently after a banquet, or after the evening meal, particularly when the patient has been very hungry because he has not eaten all day. Grollman[32] has shown that the cardiac output may increase by as much as 2 liters a minute after a heavy meal, and he suggests that this increased load on a heart with diseased coronary arteries may explain the occurrence of death after a large meal.

Cardiac infarction as a result of insulin shock and hypoglycemia has been described repeatedly.

Severe electric shock may induce angina pectoris or cardiac infarction.[33]

High altitudes, such as those attained during airplane flights, induce anoxemia which may be sufficient to cause coronary insufficiency or myocardial infarction in persons with diseased coronary arteries. Benson[34] described the case of a pilot who developed symptoms of cardiac infarction while flying over a mountain pass in California. At autopsy, extensive atheroma of the descending branch of the left coronary artery was found, but there was no myocardial infarction.

It is probable that excessive heat or humidity may at times induce cardiac infarction.[35] One of my patients had his attack in a Turkish bath.

CASE 12.—A man, aged 55, for three years had complained of pain in the calves on walking three blocks, compelling him to rest. He last obtained life insurance one year earlier. He visited a Turkish bath and remained there for two hours. As he was about to leave, he suddenly became dizzy, broke out into a sweat, and experienced substernal pressure which lasted an hour. While dressing, the pain recurred. He was then taken to a hospital, where he remained for six weeks.

Examination thirteen weeks after the onset revealed some enlargement of the left ventricle and left auricle. The first heart sound was obscured by a loud systolic murmur at the apex, which was transmitted to the axilla. The blood pressure was 110/80. The electrocardiogram showed the typical pattern of posterior infarction of the left ventricle.

CONCLUSION

I have cited case histories to illustrate the fact that the onset of cardiac infarction is often preceded by specific events that seem to be directly responsible. To the popular mind this is a common and natural sequence of events. Physicians, in spite of the fact that they may, on theoretical grounds, deny that there is any causal relationship between external factors and the development of cardiac infarction, take great pains to warn their patients with coronary artery disease against physical exertion, overeating, and sexual excitement.

Present knowledge of the physiology and pathology of the coronary circulation suggests probable mechanisms that may initiate cardiac infarction. Fundamentally, there is an upset of the balance between the nutritive needs of the heart muscle and the adequacy of the coronary blood flow, and this is sufficient to cause myocardial necrosis. Such coronary insufficiency arises most commonly because the narrowed channels of the diseased coronary arteries do not permit the passage of enough blood to satisfy the needs of the heart muscle when there are sudden calls on it for greater work; the flow of blood is decreased because of reflex narrowing of the damaged coronary arterial bed, or by hemorrhage into the coronary arterial wall, causing partial or complete occlusion of one of the coronary vessels.

The most common external factors which precipitate cardiac infarction are effort, emotion, cold, and overeating. These factors cannot cause cardiac infarction in the presence of normal coronary arteries. Just as an unhealthy tree may stand for years until blown down by a violent wind storm, so a heart, with sclerosed coronary arteries, may function for years until a sudden strain overtaxes its weakened structure and leads to cessation of heart action, or impairment of its structure and function, with progressive heart muscle damage.

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HEART DISEASE AND PUBLIC HEALTH

Current Trends and Prospects

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As I am to discuss heart disease and public health, it will avoid misunderstanding if at the outset I attempt to define what we mean by public health. It is that branch of medicine which concerns itself with the prevention and control of disease from the point of view of the community as a whole. In contrast with the practicing physician, the health officer has the people of the city, county, state, or nation as his patients, and he utilizes the resources of the community in his effort. We all know that, under modern conditions, the individual patient and the individual doctor are often helpless in combatting the spread of infection, as, for example, in controlling yellow fever, typhoid fever, or malaria. It takes the resources of the state to do that. Even in relation to such diseases as tuberculosis and syphilis, it has become a well-established principle, learned through sad experience, that not only prevention, but treatment, is properly a public health function. The individual patient, in many instances, is unable to provide himself with the care which he needs, and the community is to that extent endangered. The public interest, therefore, demands that the necessary treatment be given, even if at public expense. In all this, there is no real conflict between the public health officer and the individual practicing physician. There are broad areas of mutual interest. The wise health officer will attempt to make all practicing physicians his associates, and all good doctors will look to their health officer for guidance and support in helping them with their patients. These general principles are gradually being evolved, although they have not yet been completely crystallized. The functions of the health officer, on the one hand, and of the practicing physician, on the other, are being worked out in the light of experience and of changing conditions, and the public interest, in the last analysis, determines their mutual responsibilities.

What are the most important problems in heart disease, and what is or should be the relationship of the public health officer to them? Heart disease is the outstanding feature of the medical picture, and will be increasingly so in the future. Clearly, the health officer cannot ignore a field so wide in extent and affecting the public health so vitally. Essen-

Presented before the Annual Meeting of the American Heart Association, Cleveland, Ohio, May 30, 1941.
Received for publication June 9, 1941.
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tially, his problems in this field are the same as those of the practicing physician, although his approach and functions are necessarily different. As I have already indicated, the health officer must concern himself with those phases of heart disease in which large-scale prevention or measures of control are attainable. The well-recognized public health procedures are clearly applicable to the control of rheumatic fever and syphilis. The control of premature hypertensive and arteriosclerotic heart disease has to date received scarcely any attention from health officers. Imperceptibly shading off from the last category is the numerically most important group, which comprises cardiac disease in old people. To a greater or lesser degree, the health officer, as we shall see, can function to advantage in all of these four phases.

Rheumatic fever is today one of the foremost health problems of childhood. Between the ages of 5 and 9, deaths from it are outnumbered only by those from the four principal communicable diseases of childhood, as a group, and by pneumonia.* At the ages of 10 to 14, it is the leading cause of death. Between the ages of 15 and 25, it is second only to tuberculosis. Although it is true that the mortality from rheumatic fever has declined, the rate of fall is less than that from other diseases, so that the proportion of deaths from rheumatic fever to the total number of deaths among persons under the age of 25 has increased.

By its very nature, rheumatic fever is a disease in every phase of which the health officer can be of great help, but he has done comparatively little. He may actively participate in a case-finding program. He can take over or amplify facilities for the treatment and care of children with the disease. Practically nowhere are these facilities commensurate with the needs. His laboratory can function in research in rheumatic fever, the cause of which has thus far eluded scientific investigation, and his records may help to unravel the complex epidemiology of the disease. He can provide convalescent and sanatorium care in suitable types of institutions. In certain parts of the country he can make use of facilities built for other purposes, but which are not fully used, particularly the tuberculosis sanatoriums. Furthermore, since nonspecific factors seem to be responsible for most of the decline in rheumatic fever, public health officials can actively promote improvement in certain matters which come under their aegis or in which they have some influence, as, for example, in housing and in popular education in health and nutrition.

In the control of syphilis, the health officer has already contributed a great deal. In fact, the progress that has been made reflects the degree to which health officers have been willing and able to take responsibility, not only in finding cases but also in treatment. In the Scandinavian countries, where syphilis has been largely controlled, it has

*Since this paper was written, mortality from pneumonia has fallen below that for rheumatic fever.

been the public health service which has carried the brunt of the work. If in our country some progress in this direction has been made, there is no denying the fact that in the present national emergency, with huge numbers of young men concentrated in camps and in defense industries, and with no correspondingly increased facilities for handling the case load, we may lose the gains of the last ten years. The task of the health officer is manyfold—finding the victims of the disease, and providing adequate facilities for treatment and seeing that they are used. He needs a broad concept of his job and resourcefulness in dealing with it.

The most difficult aspect of the problem in heart disease, both for medicine and for public health, is constituted by the relatively large numbers of persons in the prime of life who fall prey to early and sometimes preventable heart and coronary artery diseases of other etiologic types. They affect men chiefly. The root of much of this problem is probably related to the process of aging of the human organism, the study of which has been scarcely begun. Fortunately, there is increasing awareness of the necessity for research on the fundamental problems involved, and a number of medical men and other scientists and public agencies are already engaging in this work. Notable is the work being done in one public institution, the Research Unit of New York City's Hospital for Chronic Diseases, and in several other places. But a greater part of our public medical resources can and should be devoted to this field.

Apart from this, however—and the wide difference between the death rate of the two sexes is, in my judgment, a good indication—a large number of early deaths from heart disease can be avoided or postponed. Many are probably due to faulty living habits with respect to the routine of daily life, or to lack of attention to infections. Intensive research and popular health education, both of which are important functions of modern public health organizations, can do a great deal in this regard.

For one thing, the health officer can help in the early detection of incipient heart disease by popularizing the periodic medical examination. In this matter a more receptive attitude on the part of the medical profession generally is much to be desired. It is admittedly true that symptoms of early heart disease are often hard, sometimes impossible, to detect, but too many patients receive little or no medical supervision until long after the disease has progressed. It may not be too early for the two professions to consider the desirability of providing public clinics for the periodic medical examination of certain groups of the population that cannot themselves afford such service.

The public health officer should consider in what ways, efficient and economical, he can utilize available medical resources in cases of early heart disease, or in acute attacks of chronic disease. For example, do we not all know of working men and women with cardiac disease who

would benefit from relatively short periods of sanatorium care, where prescribed rest and other measures would be carried out under suitable conditions, and where re-education of the patient in his way of life could be carried out better than in the atmosphere of worry and strain of the home and work place? In a few places, the overbuilt sanatorium facilities for tuberculosis, or other hospitals now unutilized, could be devoted to this purpose.

The health officer can make increasing use of the visiting nurse services under his supervision for chronic cardiac disease and, when such services are lacking, can develop or amplify them. Visiting nurses now operating very widely all over the country are of value not merely in actual bedside care, but in the broader fields of psychologic adjustment of the patient or his family, and in interpreting the doctor's instructions to them. These phases are often neglected because they take more time than the busy physician can give them. But they can be handled well by visiting nurses, particularly if nurses are given special training.

Old people with cardiovascular disease present a somewhat different set of problems which are much more difficult in character and limited in scope. The chief needs are for additional clinic facilities, for more home care, and for institutional care of the semihospital type. The numbers of aged cardiac patients are already so great and so rapidly increasing that there is urgent need for a long range program for their care. The very nature of the situation is such that a major part of the financial burden must be borne by public funds. Public health officers must recognize their responsibility here and seek the help and guidance of the whole medical profession in developing programs that are consonant with the welfare of the patients, the public, and the doctors. We cannot safely add to the burdens of voluntary hospital clinics if they are to continue to do good work. A larger number of public clinics, run by full-time men, is the only desirable solution for impoverished ambulant patients. When such patients are confined at home, public medical service may be necessary, but the work of physicians may be lightened and rendered more efficient by the proper use of visiting nurses and, in selected cases, of medical social workers. Increasing numbers may best be handled in institutions, but these cannot and need not be elaborate and costly hospitals.

Heart disease, then, presents many different tasks, responsibilities, and opportunities for public health officers. But before any large-scale advance can be made, both they and the medical profession as a whole must accept the view that heart disease is a proper field of work for the health officer. They need also to agree on the respective roles of the private and public physician.

In this respect, the problem of heart disease reminds one of the situation which prevailed in tuberculosis about thirty years ago. At that time health officers were just beginning to recognize that the problem

of the tuberculous patients was largely one for them to solve. There was considerable hesitation in entering the field, and uncertainty in developing the necessary technique and procedures. They lacked diagnostic classifications and standards, staffs trained in the special treatment of the disease, and sufficient diagnostic and sanatorium facilities for the care of patients.

What a change thirty years has brought about, thanks to the increasingly better understanding of the basic factors of the situation by both practicing physicians and the growing profession of health officers. Once it was realized that a disease so widespread, yet everywhere so concentrated among poor people, was the province of the public authorities, constructive steps, one after another, were taken by health officers and physicians in developing new procedures, with the result that, within a single generation, prodigious advances were made, not only in cutting down the ravages of the disease, and in protecting persons against it, but also in developing an understanding of the nature of the disease itself.

I am bold enough today to stress this analogy with reference to heart disease. I appreciate, of course, inherent and fundamental differences between the one disease which stems from an invasion of the body by a bacillus, and the other disease or group of diseases, the bulk of which represents sequelae of many factors, both exogenous and endogenous in nature, in the aging patient. Prevention of tuberculosis did not prove a hard nut to crack once the nature of the problem was understood and properly organized efforts were brought to bear. Prevention of heart disease will be a very different proposition because so large a part of it is the end result of accumulated insults incidental to the functioning of the body. On the other hand, there are enough phases of heart disease in which prevention is possible to excite the health officer with the real job he can do in this field.

But my major interest is the idea that the field of heart disease is fundamentally one in which the health officer can function and bear a major responsibility. There is every reason why the organized official and voluntary public health agencies should participate in the work to be done. Health officers have a tremendous contribution to make in supplementing and strengthening the efforts of the medical profession and in developing appropriate administrative procedures for the practical care of patients. For this disease, the most common in adult life, involves such long periods of disability that the medical costs are far beyond the resources of most of its victims. The very economics of the situation make it impossible for the ordinary relationships of physician and private patient to be fully effective. Thus far this situation has been met by the establishment of free or low-cost outpatient clinics in public and private hospitals, in which much of the service of the physician is rendered without compensation. Patients either cannot be

seen sufficiently often or are treated too superficially because of the crowded conditions of most of the clinics. This situation will get worse, rather than better. Obviously, we must think in terms of modifying our present types of organization and medical care for these people.

Leaders in medicine and public health must face frankly a situation as patent as this, and take the necessary steps for integrating the care of those suffering from heart disease into a general scheme, in which the proper share is borne by public funds, under the administration of the health officer, just as has been done in the case of tuberculosis. I have no illusions that this scheme can be developed overnight. The tuberculosis problem, which was simpler, took decades to get under way toward solution. But the important and first step is the acceptance by physicians and health officers of the concept that heart disease is a suitable field for similar exploitation. Then, in good will, all interested parties can get together in planning their respective parts of the job, on ways of effective cooperation, and on the sequence of steps which would be most likely to assure progress and win the support of the community.

THE VALUE OF COMBINED MEASUREMENTS OF THE VENOUS PRESSURE AND ARM-TO-TONGUE AND ARM-TO-LUNG CIRCULATION TIMES IN THE STUDY OF HEART FAILURE

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MUCH has been written on measurements of the venous pressure and circulation time of the blood in connection with various cardiovascular diseases. The value of such measurements in the diagnosis and continued observation in cases of heart failure has been especially emphasized. However, most of the clinical studies on heart failure have been concerned with one or another of these tests as an isolated procedure. Comparatively little information has been published which would indicate the importance, at times, of estimating the venous pressure and measuring the circulation time more or less simultaneously. It has been our purpose in this investigation to endeavor to appraise the value of these measurements when they are used in combination.

TECHNIQUE

The apparatus (Fig. 1) we used for combined measurements of the venous pressure and circulation times consists of a three-way stopcock to the center adaptor of which is connected, by means of rubber tubing, a calibrated glass tube of 4 mm. bore. This measuring tube is filled through the stopcock with physiologic salt solution by means of a 5 c.c. syringe. This syringe is then filled with 5 c.c. of a 20 per cent calcium gluconate* solution (or 10 per cent magnesium sulfate solution) and is attached to the stopcock. A 1.5 inch, 19 gauge needle is affixed to the other end of the stopcock. A mixture of 5 minims of ether and 5 or more minims of physiologic salt solution is placed in a 2 c.c. syringe and kept at hand.

The patient is required to rest in bed for at least fifteen minutes before the measurements are made. He is instructed in those parts of the procedure which will require his cooperation. He is requested to try to breathe regularly and naturally and to refrain from talking except as specifically directed. At the time of the measurements, the patient should be supine. The arm selected for venipuncture is abducted through an angle of about 45 degrees, and is in such a position that the antecubital veins are at, or slightly below, the plane of the right atrium. The location of this plane is indicated on the side of the patient's chest by placing a mark 10 cm. from the plane of his back. This mark serves as the zero level for measurement of the venous pressure. It has been demonstrated[1] that this method

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Received for publication April 9, 1941.

*Calcium gluconate was supplied as ampoules of 20 per cent Neocalglucon by the Sandoz Company.

of allocating the plane of the right atrium is more exact than older methods which took their measurements from the front of the chest. Occasionally, when the patient is too dyspneic, because of pulmonary congestion, to lie flat in bed, the venous pressure and circulation times must be estimated with him in a sitting position. When this is the case, the plane of the right atrium is considered to be at the level of the fourth rib. However, it has been our experience that the venous pressure cannot be measured so accurately under these conditions.

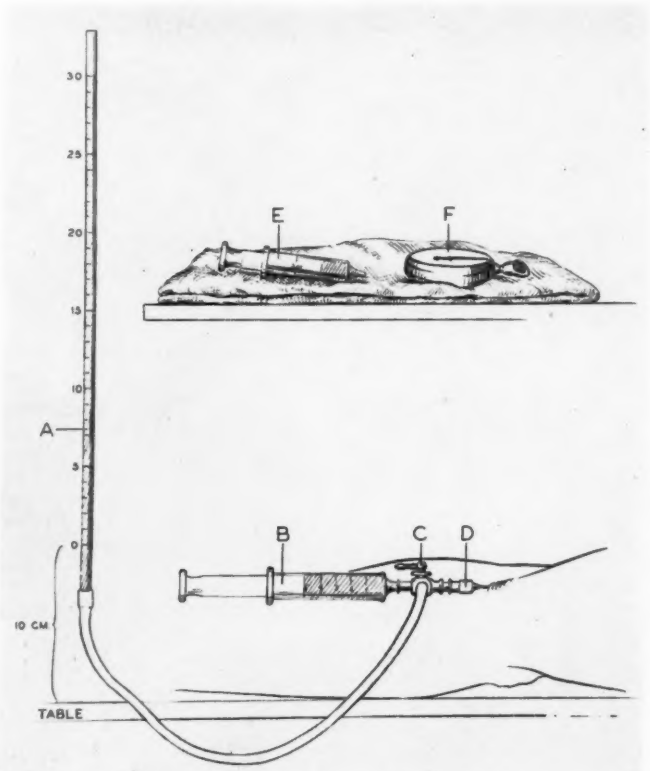

Fig. 1.—Apparatus for measurement of circulation times and venous pressure. *A*, Calibrated tube; *B*, 5 c.c. syringe; *C*, three-way stopcock; *D*, 19 gauge needle; *E*, 2 c.c. syringe; *F*, stop watch. (From The Practitioner's Library, Supplement Volume, New York, 1940, D. Appleton-Century Co., Inc.)

The needle of the apparatus is introduced into one of the antecubital veins, according to the usual technique for venipuncture. When the tourniquet is removed from the patient's arm, ten to fifteen seconds are allowed to pass in order to permit the restoration of venous flow that has been retarded by the tourniquet. Then the calcium gluconate or magnesium sulfate is injected as rapidly as possible. The interval from the beginning of this injection until the patient says "Hot," at the moment of perception of a hot sensation in his throat and tongue, is measured with a stop watch, and represents the arm-to-tongue circulation time. It ranges in normal persons from nine to sixteen seconds.

As soon as the first injection is completed, the lever of the stopcock is turned so that salt solution will begin to enter the vein from the glass measuring tube. Next, the 5 c.c. syringe is replaced at the stopcock by the smaller syringe contain-

ing the ether-saline mixture. Meanwhile, the zero point of the glass measuring tube is placed at the mark on the patient's chest which designates the plane of the right atrium. The column of saline in the tube will continue to fall, fluctuating slightly with respiration, and finally comes to rest at a height which indicates the venous pressure in terms of millimeters of saline. The patient's abdomen is then compressed at the right upper quadrant for thirty to sixty seconds, in order to record the effect of this procedure upon the height of the venous pressure.[2] Compression of the abdomen should be firm, but should not interfere with the regularity or depth of the patient's breathing. Normally, the venous pressure varies from 50 to 150 mm. of saline, and, when the abdomen is compressed, there is no rise or a rise of less than 10 mm.

After the venous pressure has been measured, the patient is warned that the next part of the procedure will require his active cooperation. The lever of the stopcock is returned to its original position, and the ether-saline mixture is injected as rapidly as possible into the vein. The interval from the beginning of this injection until the patient perceives the odor of ether, and says "Now," is measured by means of a stop watch, and represents the arm-to-lung circulation time. Occasionally the operator will smell the ether on the patient's breath before the patient speaks. In this event the end point of the measurement is the moment at which the operator detects the odor. Normally, the arm-to-lung circulation time ranges from 3.5 to eight seconds. It is now possible to compute the lung-to-tongue circulation time by ascertaining the difference between the two circulation times already estimated. The lung-to-tongue circulation time normally varies between five and twelve seconds.

HEART FAILURE

The measurements were recorded, according to the technique described above, in 100 consecutive cases of congestive heart failure of varying severity and under varying conditions of treatment. The cases comprised a number of different etiological types of heart disease (Table I). The number of times the measurements were performed in each case ranged from one to eight, depending upon whether or not it was desirable or feasible to repeat them as a part of the observation of the patient's clinical course. A total of 185 measurements were made in the 100 cases (Table II).

The patient with heart disease who develops symptoms and signs of general heart failure always shows abnormalities in these measurements. Thus, the venous pressure usually is considerably above 150 mm. of saline, and rises quickly and significantly when the right upper quadrant of the abdomen is compressed. The arm-to-tongue circulation time is prolonged beyond sixteen seconds, and the arm-to-lung circulation time, as measured with ether, is more than nine seconds. Practically all of the patients in this series had measurements characteristic of general heart failure. Thus, 148 measurements which were made in eighty-nine of the 100 cases indicated the presence of general heart failure. The highest venous pressure obtained initially in this series of patients with heart failure was 335 mm. of saline, with a rise to 390 mm. when the right upper quadrant of the abdomen was compressed. The longest

arm-to-tongue circulation time, as measured with calcium gluconate, was seventy-five seconds. The longest arm-to-lung time, as measured with ether, was thirty-four seconds.

TABLE I

ETIOLOGICAL CLASSIFICATION OF CASES OF HEART FAILURE

DIAGNOSIS	NO. OF CASES
Rheumatic heart disease	13
Hypertensive heart disease	57
Syphilitic heart disease	14
Coronary arteriosclerosis	8
Hyperthyroid heart disease	3
Beriberi heart disease	2
Heart disease due to anemia	1
Undetermined etiology	2
Total	100

In cases in which the heart failure responds to treatment, there is a tendency for these values to return more or less promptly to normal. Usually, the arm-to-lung circulation time is the first to be restored. Even when this time has reached a normal value and the initial venous pressure measurement is no longer above 150 mm. of saline, the tendency of the venous pressure to rise significantly when the abdomen is compressed may persist for a variable length of time. In thirty-three of the cases of heart failure the arm-to-lung circulation time was normal, but measurement of the venous pressure indicated the existence of right ventricular failure, either by an initially high reading or by a significant rise when the abdomen was compressed. Three of the thirty-three patients had hyperthyroid heart disease.

The arm-to-tongue circulation time sometimes remains prolonged for a considerable period after the other values have returned to normal. This is particularly true in cases of hypertensive, arteriosclerotic, and syphilitic heart disease. There were thirteen cases in our series in which this was observed. In an occasional case of this type the arm-to-tongue circulation time apparently never reaches a normal value, indicating presumably that some degree of left ventricular failure remains.

In some cases of heart failure, the clinical manifestations are indicative only of failure of the left ventricle during the entire time that the patient is under observation. Of course, after a variable length of time, manifestations of right ventricular failure may ensue. When there is failure of the left ventricle only, the venous pressure and arm-to-lung circulation time remain relatively normal, but the arm-to-tongue circulation time is prolonged. In seven of the 100 cases in our series the clinical manifestations were those of isolated left ventricular failure, and the circulation measurements were in keeping with this diagnosis. When the venous pressure or circulation time is measured for the first time

TABLE II

RESULTS OF MEASUREMENT OF VENOUS PRESSURE AND CIRCULATION TIMES IN 100 CASES OF HEART FAILURE

CASE NO.	ETIOLOGY	DATE	TREATMENT	SIGNS OF HEART FAILURE	VENOUS PRESSURE	RIGHT UPPER QUADRANT COMPRESSION	ARM-TO-TONGUE CIRCULATION TIME	ARM-TO-LUNG CIRCULATION TIME	LUNG-TO-TONGUE CIRCULATION TIME
1	1	10/10/39	U.	E., T., P.	150	180	C. 26.5	Et. 11	15.5
		10/14/39	P.D.	E., T., P.	185	250	C. 48	Et. 9	39
		10/23/39	D.	E., P.	165	250	M. 38	Et. 15	23
		10/30/39	D.	E., T., P.	220	300	M. 65	Et. 18	47
2	2	10/13/39	U.	E., P.	250	300	C. 22	Et. 7	15
		10/17/39	P.D.	E.	130	150	C. 16	Et. 6	10
		10/26/39	D.	O.	110	110	M. 14	Et. 4.5	9.5
3	2	4/26/39	P.D.	T.	120	130	C. 26	Et. 7	19
4	2	7/13/40	U.	T., P.	135	225	C. 45?	Et. 5.5	39.5
		7/17/40	P.D.	O.	170	195	C. Blank	Et. 10	
5	2	5/ 2/39	D.	E., T., P.	190	280	C. 26	Et. 10	16
6	1	4/28/39	U.	EE.,T., P.	320	360	C. 55	Et. 22	33
		5/ 3/39	D.	E., T., P.	270	300	C. 47	Et. 15	32
		5/ 8/39	D.	E., T., P.	220	250	C. 32	Not done	
7	6	10/29/39	U.	E., T., P.	165	185	M. 22	Et. 6	16
8	1	7/ 6/39	D.	T., P.	160	235	C. 18.5	Not done	
		7/10/39	D.	T., P.	125	165	C. 26	Et. 6	20
9	2	11/27/39	D.	T.	250	300	M. 41	Et. 14	27
10	3	12/26/38	U.	EE., T., P.	165	185	C. 47	Et. 9.5	37.5
		12/30/38	P.D.	T., P.	130	180	C. 35	Et. 13	22
		1/ 4/39	D.	T., P.	165	180	C. 30	Et. 17	13
		1/ 9/39	D.	T., P.	150		C. 37	Et. 27	10
11	2	12/ 3/38	U.	T., P.	250	300	C. 37.2	Et. 13	24.2
		12/14/38	D.	O.	110	120	C. 27	Et. 12	15
12	?	11/23/39	U.	EE., T., P.	335	390	M. 30	Et. 9	21
13	2	11/25/39	D.	P.	220	240	M. 19	Et. 11	8
14	3	1/ 3/39	D.	T., P.	130	150	M. 35	Not done	
15	1	6/ 8/39	P.D.	EE., T., P.	215	230	C. 37.5	Et. 12.5	25
16	1	6/10/39	U.	P.	115	140	C. 12	Et. 8	4
		6/25/39	U.	P.	160	250	C. 35	Et. 10	25
17	6	4/20/39	U.	E., T., P.	220	290	C. 26	Et. 21	5
18	2	1/ 3/40	U.	EE., T., P.	320	360	M. 55	Not done	
19	3	2/17/40	D.	T., P.	110	140	M. 26	Pa. 14	12
20	2	1/24/40	D.	T., P.	140	180	C. Blank	Et. 17	
21	2	12/ 4/39	U.	E., T., P.	155	175	M. 26	Et. 8.5	17.5
22	1	3/14/40	D.	EE., T., P.	300	350+	M. 36	Pa. 46 1.5 c.c.	-10
23	5	2/ 9/40	U.	E., T.	155	190	M. 13	Pa. 6	7
		2/15/40	D.	T.	85	75	M. 9	Pa. 6	3
		2/27/40	U.	E., T., P.	160	190	M. 10	Pa. 6	4
24	2	3/16/40	D.	E.	110	130	M. 25	Pa. 20 1 c.c.	5
25	2	3/20/40	D.	E., P.	190	210	M. 25	Pa. 25 1 c.c.	0
26	2	3/31/39	U.	E., T., P.	300	360	C. 26	Et. 9	17

TABLE II—CONT'D

CASE NO.	ETIOLOGY	DATE	TREATMENT	SIGNS OF HEART FAILURE	VENOUS PRESSURE	RIGHT UPPER QUADRANT COMPRESSION	ARM-TO-TONGUE CIRCULATION TIME	ARM-TO-LUNG CIRCULATION TIME	LUNG-TO-TONGUE CIRCULATION TIME
27	2	4/12/39	P.D.	T., P.	230	265	C. 23	Et. 8.2	14.8
		4/25/39	D.	E., T.	185	190	C. 15.8	Et. 6.6	9.2
28	2	3/24/39	U.	T., P.	240	270	C. 46	Et. 20	26
		3/28/39	P.D.	T., P.	125	190	C. 26	Et. 11	15
29	2	3/30/39	D.	EE., T., P.	270	350	C. 39	Et. 18	21
30	2	3/ 9/39	U.	EE., T., P.	280	310	C. 24	Et. 8	16
		3/14/39	D.	T., P.	135	160	C. 25.5	Et. 7.5	18
		3/18/39	D.	P., D.	Not done		C. 25	Et. 14	11
31	2	3/13/39	U.	E., P.	170	185	C. 19	Et. 10	9
32	2	3/ 8/39	U.	E., T., P.	260	300	C. 44?	Et. 34	10
		3/10/39	P.D.	E., T., P.	270	300	C. 60	Et. 8	52
		3/14/39	D.	E., T., P.	110	115	C. 20	Et. 6	14
33	2	3/ 6/39	U.	E., T., P.	140	170	C. 60	Not done	
		3/13/39	D.	O.	75	80	C. 20	Et. 10	10
34	2	3/ 4/39	P.D.	E.	150	195	C. 18	Et. 9	9
		3/10/39	D.	O.	90	100	C. 15	Et. 8	7
35	1	2/ 7/39	P.D.	P.	150	180	C. 39	Et. 9	30
		2/17/39	D.	P.	150	165	C. 45	Et. 11	34
36	4	2/ 8/39	U.	EE., T., P.	230	300	C. 20	Et. 10	10
		2/13/39	P.D.	E., T., P.	120	165	C. 19	Et. 6	13
		2/19/39	D.	T.	60	70	C. 21	Et. 6	15
		2/24/39	D.	T.	120	150	C. 18	Et. 8	10
37	3	2/13/39	D.	E., P.	140	185	C. 35	Et. 10	25
38	2	2/26/39	U.	E., T., P.	260	Not done	C. Blank	Et. 40?	
		3/ 2/39	D.	E., T., P.	125	150	C. 36	Et. 5	31
39	2	2/ 4/39	D.	E., T., P.	270	310	C. 75	Et. 20	55
		2/ 8/39	D.	E., T., P.	230	260	C. 22	Et. 11	11
		2/12/39	D.	E., T., P.	190	220	C. 40	Not done	
40	2	2/ 2/39	U.	EE., T., P.	275	310	C. 45	Et. 20	25
		2/ 6/39	D.	EE., T., P.	260	310	C. ?	Et. 19	
		2/11/39	D.	E., T., P.	230	300	C. 45	Not done	
		2/25/39	D.	E., T., P.	315	335+	C. 35	Et. 11	24
		3/ 4/39	D.	E., T., P.	280	320	C. 33	Et. 22	11
41	3	12/ 1/38	U.	E., P.	170	195	C. Blank	Et. 25.8	
		12/ 4/38	P.D.	E., P.	180	190	C. Blank	Et. 24.8	
		12/ 9/38	D.	P.	160	170	C. 20	Et. 16	
42	2	10/13/39	U.	EE., T., P.	215	290	C. Blank	Et. 15	
43	2	10/16/39	P.D.	T., P.	160	200	C. 24	Et. 10	14
		10/23/39	D.	O.	165	175	M. 15	Et. 10	5
		10/30/39	D.	O.	50	60	M. 10	Et. 5.5	4.5
44	2	7/24/39	U.	EE., T., P.	225	375	C. 34	Et. 9	25
45	2	10/29/39	D.	T., P.	80	120	M. 40	Et. 26	14
		11/ 2/39	D.	P.	160	185	M. 50	Et. 12	38
46	2	11/10/39	P.D.	O.	275	300	Not done	Not done	
		11/24/39	D.	O.	275	350	M. 70	Et. 10	60

TABLE II—CONT'D

CASE NO.	ETIOLOGY	DATE	TREATMENT	SIGNS OF HEART FAILURE	VENOUS PRESSURE	RIGHT UPPER QUADRANT COMPRESSION	ARM-TO-TONGUE CIRCULATION TIME	ARM-TO-LUNG CIRCULATION TIME	LUNG-TO-TONGUE CIRCULATION TIME
47	3	12/ 8/39	U.	E., T., P.	225	285	C. 42	Et. 19.5	22.5
		12/12/39	D.	P.	90	110	C. 62	Et. 12	50
		12/20/39	D.	P.	65	75	C. 26	Et. 10	16
		12/26/39	D.	O.	120	130	C. 51	Et. 12	39
		1/ 2/40	D.	O.	80	100	C. 45.5	Et. 19	26.5
48	1	12/ 8/38	U.	E., P.	160	210	C. 68	Et. 17.5	50.5
		12/12/38	P.D.	P.	85	85	C. 55	Et. 12	43
		12/20/38	D.	P.	20	20	C. 40.4	Et. 13.8	26.6
49	3	1/12/39	U.	P.	90	120	C. 45	Et. 12	33
		1/18/39	D.	O.	75	80	C. 40	Et. 16	24
50	3	1/ 7/39	U.	E., T., P.	135	160	C. 45	Et. 5.5	39.5
		1/11/39	P.D.	P.	135	145	C. Blank	Et. 13.2	
		1/19/39	D.	P.	65	70	C. 22	Et. 12	10
51	2	1/12/39	D.	T., P.	245	255	C. 37	Et. 17	20
52	2	1/28/39	D.	E., T., P.	185	225	C. Blank	Et. 15	
		2/ 1/39	D.	P.	115	160	C. 25	Et. 10	15
		2/ 5/39	D.	O.	100	150	C. 15	Et. ?	
		2/ 9/39	D.	P.	130	160	C. 41	Et. 20	21
53	2	1/25/39	U.	EE., T., P.	185	225	C. 32	Et. 20	12
		1/30/39	D.	E., P.	60	85	C. 24	Et. 5	19
		2/ 3/39	D.	O.	55	60	C. 24	Et. 6	18
		2/10/39	D.	O.	110	130	C. 30	Et. 6	24
54	5	1/18/39	U.	E., T., P.	230	260	C. 16	Et. 13	3
		1/22/39	P.D.	E., T., P.	220	260	C. 29	Et. 9	20
		2/ 1/39	D.	E., T.	160	200	C. 15	Et. 7	8
		2/ 5/39	D.	E., T.	150	180	C. 14	Not done	
		2/ 9/39	D.	E., T.	160	185	C. 12.5	Not done	
		2/16/39	D.	E., T.	125	140	C. 12	Not done	
		2/23/39	D.	E., T.	85	90	C. 12.5	Not done	
		3/ 2/39	D.	E., T.	80	95	C. 13	Not done	
55	3	11/18/38	U.	E., T., P.	195	230	C. Blank	Et. 5	
		11/22/38	P.D.	E., P.	105	125	C. 27	Et. 5.4	21.6
		11/29/38	D.	P.	110	150	C. 22	Et. 11	11
		12/ 6/38	D.	P.	85	125	C. 50	Et. 9.5	41.5
56	2	11/14/38	P.D.	E., P.	210		C. 31	Et. 9	22
		11/18/38	D.	O.	80		C. 20	Et. 4.5	15.5
57	2	11/15/38	U.	E., T., P.	170	185	C. 29.8	Et. 12	17.8
		11/19/38	P.D.	T.	80	80	C. 25	Et. 8.5	16.5
		11/29/38	D.	T.	85	85	C. 23	Et. 9.6	13.4
		12/ 6/38	D.	T., P.	100	110	C. Blank	Et. 8	
		12/12/38	D.	T.	95	95	C. 28	Et. 10	18
58	2	12/ 5/39	U.	E., T., P.	175	190	C. 17	Et. 8	9
59	7	12/ 3/38	U.	E., P.	110	155	C. 19	Et. 10	9
60	2	3/30/39	D.	O.	80	95	C. Blank	Et. 9	
		4/ 3/39	D.	O.	130	145	C. 26	Et. 15	11
61	2	10/16/39	D.	O.	100	105	C. 16	Et. 8	8
62	2	2/16/39	U.	O.	125	130	C. 12	Et. 8	4
63	2	11/17/38	D.	O.	95	115	C. 20.6	Et. 10.6	10
64	2	11/29/38	P.D.	O.	120	155	C. 17	Et. 8	9

TABLE II—CONT'D

CASE NO.	ETIOLOGY	DATE	TREATMENT	SIGNS OF HEART FAILURE	VENOUS PRESSURE	RIGHT UPPER QUADRANT COMPRESSION	ARM-TO-TONGUE CIRCULATION TIME	ARM-TO-LUNG CIRCULATION TIME	LUNG-TO-TONGUE CIRCULATION TIME
65	4	10/17/39	U.	P.	50	50	C. 24	Et. 8	16
66	?	4/26/40	D.	E., T., P.	160	180	C. 11.6	Et. 5.8	5.8
67	4	7/13/39	U.	O.	135	160	C. 15	Et. 5.5	9.5
		7/17/39	U.	O.	125	125	C. 25	Et. 6	19
68	2	5/ 8/39	U.	T., P.	120	120	C. 34	Et. 10	24
69	1	3/19/40	D.	T.	100	150	M. 13.5	Pa. 22 0.5 c.c.	
70	3	3/16/40	D.	T., P.	70	80	M. 20	Pa. 13 1 c.c.	7
71	5	3/31/39	U.	T.	175	200	C. 8.5	Et. 4.2	4.3
		4/ 5/39	U.	T., P.	130	145	C. 8	Et. 4	4
		4/25/39	D.	O.	130	130	C. 7.4	Et. 6	1.4
72	2	3/15/39	U.	T., P.	145	145	C. 30	Et. 10	20
		3/21/39	U.	T.	80	75	C. Blank	Et. 10	
73	2	3/15/39	U.	E., T., P.	120	145	C. 15	Et. 7	8
		3/21/39	D.	O.	85	95	C. 20	Et. 8	12
74	2	2/26/39	D.	T., P.	60	60	C. 120?	Et. 11	109?
		3/ 6/39	D.	T., P.	60	60	C. 35	Et. 19	16
		4/ 7/39	D.	E., P.	150	150	C. 32	Et. 18	14
75	2	1/26/39	U.	EE., T., P.	220	280	C. 18	Et. 9.5	8.5
		1/31/39	P.D.	E., T., P.	100	180	C. 17	Et. 9.6	7.4
		2/ 4/39	D.	P.	40	100	C. 11	Et. 5	6
		2/11/39	D.	O.	45	45	C. 11	Et. 5	6
76	4	11/21/39	P.D.	T., P.	140	140	C. 57	Et. 20	37
77	2	3/24/39	P.D.	P.	115	130	C. 23	Et. 8	15
78	4	11/24/39	D.	O.	60	60	M. 19	Et. 9	10
79	1	7/10/40	D.	O.	290		C. 30.4	Et. 16.8	13.6
80	2	8/13/40	P.D.	EE., T., P.	165	315	C. 45	Et. 25	20
81	2	8/21/40	P.D.	E.	180	210	M. 22.8	Et. 11	11.8
82	2	9/14/40	P.D.	EE., T., P.	280+	?	C. 28	Et. 12	16
83	1	9/ 6/40	D.	E., P.	150	175	C. 35.8	Et. 16	19.4
		9/11/40	D.	E.	95	115	C. 16	Et. 6.8	9.2
84	3	7/16/40	D.	E., P.	200	230	M. 30	Et. 15	15
85	4	7/31/40	D.	O.	158	165	M. 19.6	Et. 10	9.6
86	2	7/11/40	U.	P.	160	175	M. 24	Et. 15	8
87	1	7/ 8/40	D.	O.	150	155	M. 19	Et. 12.6	6.4
88	2	7/ 9/40	U.	E., P.	180	200	M. 21	Et. 9	12
		8/ 2/40	D.	O.	120	130	M. 16	Et. 9	7
89	3	9/ 6/40	P.D.	E., P.	190	220	M. 26	Et. 12.2	13.8
90	1	7/19/40	D.	O.	140	150	M. 22	Et. 12.2	9.8
91	2	8/13/40	U.	E.	160	175	M. 19	Et. 10	9
92	2	8/20/40	D.	O.	135	135	M. 23	Et. 9	14
93	2	7/11/40	D.	E.	140	155	M. 17	Et. 13.4	3.6
94	2	7/13/40	P.D.	E., P.	200	225	M. 60	Et. 42	18
95	2	7/12/40	D.	E.	160	170	M. 30	Et. 12.6	17.4
96	3	8/25/40	U.	E., P.	160	180	M. 65.2	Et. 22.4	42.8
97	3	9/ 6/40	D.	E., P.	200	230	M. 38	Et. 15	23
98	4	8/31/40	D.	E., P.	100	110	M. Blank	Et. 13	
99	2	8/ 9/40	D.	E., P.	210	235	M. 65?	Et. 14	
100	4	8/ 7/40	P.D.	O.	50	50	M. 21.8	Et. 10	11.8

1, Rheumatic heart disease; 2, hypertensive heart disease; 3, syphilitic heart disease; 4, coronary arteriosclerosis; 5, hyperthyroid heart disease; 6, beriberi heart disease; 7, severe anemia. U., Untreated; P.D., partially digitalized; D., completely digitalized; E., edema; EE., anasarca; T., tachycardia; P., pulmonary congestion; O., none; C., calcium gluconate; Et., ether; M., magnesium sulfate; Pa., paraldehyde.

after a patient with heart failure has been treated with rest in bed or digitalis, or both, it is not uncommon to find that the measurements are within normal limits. There were four such cases in the group of 100 cases. This fact serves to emphasize that estimations of the venous pressure and circulation time should be made early and repeatedly if they are to have full diagnostic value, particularly in cases of mild heart failure.

Isolated failure of the right ventricle, in our experience, has been rare. There were no such cases in our series. This type of heart failure is said to cause elevation of the venous pressure and prolongation of both the arm-to-lung and arm-to-tongue circulation time, but the lung-to-tongue circulation time is not prolonged.[2] In this connection, thirty-four of the patients with general heart failure had measurements within normal limits for the lung-to-tongue circulation time. Thirty-seven such measurements were obtained in these cases. This seems to impair, on theoretical grounds, the value of the lung-to-tongue circulation time measurement in the diagnosis of isolated right ventricular failure.

It is interesting that, in a considerable number of instances, edema was absent, in spite of the fact that the venous pressure was abnormal. There were twenty-three instances of this type in which the venous pressure was above 150 mm. of saline; the highest measurement was 275 mm. In addition, there were forty-three instances in which the initial venous pressure measurement was within normal limits, but compression of the abdomen indicated persistence of right ventricular failure. There were two other instances of this latter type that are difficult to evaluate because the other measurements were normal and signs of heart failure had disappeared. These facts would seem to demonstrate that a careful measurement of the venous pressure is a reasonably accurate method of detecting the presence of right ventricular failure when other signs are lacking.

In cases in which the venous pressure and circulation times are measured repeatedly during the course of heart failure, the progress of the patient can be followed objectively. This manner of using the circulation tests can best be exemplified by illustrative cases.

CASE REPORTS

CASE 2.—The patient was a 64-year-old white man who was in the hospital for seventeen days because of heart failure due to hypertensive heart disease. On the day of admission his venous pressure was 250 mm. of saline, and it rose to 300 mm. with abdominal compression. The arm-to-tongue circulation time was twenty-two seconds; the arm-to-lung time, seven seconds. At this time there was evidence of pulmonary congestion and moderate edema. Four days later, when the patient was partially digitalized, the signs of heart failure had subsided except for slight edema. On this day the only abnormality in the circulation measurements was a significant rise of the venous pressure from 130 mm. to 150 mm. during abdominal compression.

By the time the patient was fully digitalized all evidence of heart failure had disappeared. The venous pressure and circulation times were entirely normal within two weeks of the day of admission.

In this case the measurements under discussion afforded confirmatory evidence of the progressive improvement of the patient. The final readings indicated that he had recovered completely from this attack of heart failure.

CASE 1.—The patient was a 39-year-old colored woman with long-standing rheumatic heart disease. There was evidence of involvement of the aortic and mitral valves. At the time of her admission to the hospital she was thought to have moderately severe heart failure, as indicated by the usual signs. At this time the circulation measurements were as follows: venous pressure, 150 mm., rising to 180 mm., with abdominal compression; arm-to-tongue circulation time, 26.5 seconds; arm-to-lung circulation time, eleven seconds.

By the fifth hospital day the patient was partially digitalized and appeared somewhat improved. However, the measurements showed little change. The venous pressure was 185 mm., and rose to 250 mm. with abdominal compression, and the arm-to-tongue and arm-to-lung circulation times were, respectively, forty-eight seconds and nine seconds. By the time the patient had been in the hospital for two weeks and was fully digitalized the measurements still failed to show significant improvement, and, at the end of three weeks, they could be interpreted as indicating aggravation of the heart failure. At this time the venous pressure was 220 mm., and rose to 300 mm. with compression of the abdomen, and the circulation times were sixty-five seconds and eighteen seconds.

In this case these measurements provided a means of demonstrating that the patient's heart failure was essentially unchanged at a time when she seemed otherwise to be improving. They further showed, objectively, the tendency of the heart failure to grow steadily worse. When values of this type are obtained on a patient with uncomplicated heart failure, the prognosis is almost uniformly quite grave.

CASE 52.—This patient was a 67-year-old white man; he had hypertensive heart disease with cardiac enlargement, auricular fibrillation, and heart failure. He had been digitalized because of heart failure some months before admission to the hospital, and had been taking a daily maintenance dose of digitalis. However, symptoms and signs of heart failure reappeared, and, at the time of entrance to the hospital, the patient was dyspneic and edematous. Circulation measurements on the first hospital day confirmed the diagnosis of general heart failure. The venous pressure was 185 mm. of saline, and rose to 225 mm. with abdominal compression. The arm-to-tongue circulation time was not measured because calcium gluconate failed to produce a sensation of warmth. The arm-to-lung circulation time was fifteen seconds. The patient improved during the ensuing week, with rest in bed, the administration of diuretics, and restriction of liquid and salt intake. On the fourth hospital day the circulation measurements were more nearly normal, and, on the eighth hospital day, the only remaining abnormality was a significant rise of the venous pressure (from 100 mm. to 150 mm.) with abdominal compression. By this time the patient felt very well, and all signs of heart failure had disappeared. It was therefore deemed safe to allow him to begin some activity. The fallacy of this judgment was well demonstrated by the final measurements which were obtained after resumption of slight activity. The venous pressure was 130 mm., and rose to 160 mm. with compression of the abdomen. Both the arm-to-lung and arm-to-tongue circulation times were prolonged to twenty seconds and forty-one seconds, respectively.

This case further demonstrates the utility of objective methods of estimating the state of cardiac hemodynamics. The effect of resumption of physical activity on the patient with heart failure can best be judged by the use of such methods. This is especially true in the case of patients with heart failure for whom a protracted period of rest in bed is prescribed. Such patients commonly experience breathlessness and weakness on first getting out of bed. It is then hard to ascertain, except by measurements of the venous pressure, circulation time, or vital capacity, whether these symptoms are the result of recurring heart failure or of the kind of physical atony which follows long rest in any disease.

CASE 3.—This patient was a 29-year-old negro who entered the hospital because of hypertensive heart disease with heart failure. On the day after admission, with the patient partially digitalized, the only remaining physical evidence of heart failure was tachycardia. On this day the venous pressure was 120 mm., and rose to 130 mm. with abdominal compression; the arm-to-tongue circulation time was twenty-six seconds; and the arm-to-lung time was seven seconds. The patient remained in the hospital for ten days and was discharged as improved.

The circulation measurements in this case were more or less typical for isolated left ventricular failure. It should be re-emphasized that measurement of the arm-to-tongue circulation time is the only one of the methods under discussion which will confirm the diagnosis of isolated failure of the left ventricle.

DISCUSSION

Perusal of the results of the circulation measurements in this series of 100 cases reveals certain discrepancies. Not all of these discrepancies are easily explained, and this probably would be true in any study of similar magnitude. For example, in a number of instances the venous pressure was found to be high, although the circulation time measurements were within normal limits. This kind of discrepancy has already been mentioned in the analysis of cases of general heart failure, where it was pointed out that in thirty-three cases the arm-to-lung circulation time was normal, although the venous pressure measurement indicated the presence of right ventricular failure. In addition, there were twenty-two cases in which the arm-to-tongue circulation time was normal in spite of the fact that the venous pressure and other manifestations indicated that heart failure was present. Three of these twenty-two patients had hyperthyroid heart disease.[3] The remaining nineteen cases included all the other etiological types in the series except beriberi heart disease. It should be mentioned, however, that measurements of this kind were much more constantly present in the cases of hyperthyroid heart disease than in the other cases. It is interesting that none of the measurements were of this type in the two cases of beriberi heart disease in our series. This is mentioned only because beriberi heart disease is considered to be an important cause of elevation of the venous pressure in the presence of a normal circulation time.[4]

There were a number of instances in the series in which the venous pressure was normal but the circulation time was prolonged. This has already been discussed above, in connection with isolated left ventricu-

lar failure. However, in fifteen other cases, both the arm-to-lung and arm-to-tongue circulation times were slightly longer than normal, although the venous pressure was unaffected. This occurred in every case at a time when all other manifestations of heart failure had disappeared. It is therefore difficult to explain except as the result of error due to human fallibility, or by assuming that in some instances the circulation time may exceed the figure accepted as the upper limit of normal without indicating that heart failure is present.

It has been our experience that difficulties in the interpretation of the circulation measurements arise mainly from errors in technique. Since cooperation by the patient is indispensable if accurate measurements are to be secured, sufficient time must be taken beforehand to explain exactly what the patient must do. In this connection, the rate and character of respiration are very important. The patient may hold his breath or breathe too rapidly during measurement of the circulation time. Irregular breathing is especially common when ether is used for the arm-to-lung time, because of the pain which is sometimes felt along the course of the injected vein. Even when the patient is forewarned, such pain may cause him to hold his breath momentarily, thereby detracting from the accuracy of the measurement. In the same way, talking or coughing by the patient may significantly alter the results.

Excessive nervousness on the part of the patient may interfere with the measurements. It is essential that he be quiet during the procedure, especially if an accurate estimation of the venous pressure is to be obtained. Obviously, mental aberration or coma may prevent employment of those parts of the procedure which require active cooperation by the patient. An example is the measurement of the arm-to-tongue circulation time by means of calcium gluconate or magnesium sulfate.

The presence of hyperthyroidism may give rise to apparent discrepancies.[3] In this condition, circulation time measurements may vary considerably, depending upon the severity of the hyperthyroidism and whether or not heart failure is present. Even with severe heart failure, the velocity of blood flow may remain relatively normal in the hyperthyroid patient. In general, therefore, estimation of the venous pressure is the only part of the procedure which is reliable for detecting the presence and following the course of hyperthyroid heart disease. The same is true, but to a lesser degree, in beriberi heart disease,[4] heart failure due to severe anemia,[5] and heart failure complicated by high fever.[3]

Pleural, pulmonary, or mediastinal disease sometimes interferes with the accuracy of the circulation measurements. Pleural or pulmonary disease of a type which alters the intrathoracic pressure may produce changes in the venous pressure and circulation time. However, lesions of this character usually give obvious physical signs, so that confusion in the interpretation of the results of measurements of the venous pres-

sure and circulation time is unlikely. On the other hand, mediastinal lesions, particularly aneurysm or other tumor, may cause remarkable alterations in the venous current in the upper extremities by compressing the superior vena cava or one of its tributaries, and, at the same time, may escape notice in the course of the usual physical examination.[6] Such lesions, therefore, may occasionally lead to misinterpretation of the circulation measurements. This is also true, but more rarely, in cases of obstruction of the peripheral veins.

There is some variation in the results of measurement of the circulation time, depending on the nature and amount of the substance employed. This is even more pronounced when the velocity of blood flow is diminished, as, for example, in heart failure. For measurement of the total circulation time, 5 c.c. of a 20 per cent calcium gluconate solution and 5 to 6 c.c. of a 10 per cent magnesium sulfate solution apparently give equally good results. Early in the course of our study we employed 2.5 c.c. of a 20 per cent calcium gluconate solution, but this amount commonly failed to produce a reaction in patients with a prolonged circulation time. Therefore, the larger dose of 5 c.c. is now usually employed. Paraldehyde is much less reliable than ether for measurement of the arm-to-lung circulation time.[7] Furthermore, the accuracy of the test with ether is enhanced if the operator attempts in each case to verify the end point by smelling the patient's breath for the odor of the drug. No serious reaction occurred as the result of administering any of the drugs used in the study.

The wide range of the normal limits for the circulation time measurements is another factor which theoretically may account for some difficulty in accurate interpretation of results. For example, an arm-to-tongue circulation time of sixteen seconds may be normal for one patient and indicative of heart failure in another. This fact constitutes an important argument for the use of more than one method in the study of a patient with heart failure. The other reasons for using more than one method have already been implied and include mainly the apparent discrepancies observed in some cases of general heart failure in which the venous pressure is abnormally elevated and the circulation time normal, or vice versa. From our results, it may safely be judged that, if the venous pressure and arm-to-tongue circulation time are measured in each case of cardiac failure, failure to obtain an accurate estimate of the state of cardiovascular hemodynamics will be rare. Probably the arm-to-lung circulation time measurement is less important except in rare etiological types of heart disease. Although the range of normal limits for the venous pressure also is wide, less difficulty is experienced in the interpretation of measurements near the upper limit of normal because of the added information secured when the effect on the venous pressure of compression of the abdomen is observed.

Venous pressure measurement might well serve as the sole objective test for heart failure if it were not for the fact that it is unaffected in cases of isolated left ventricular failure.

While our main inquiry in this study was with reference to the use of circulation measurements in cases of heart failure, other cases naturally crept in. These were all cases in which heart failure was suggested by one or more prominent symptoms. These cases are mentioned in order to emphasize the further utility of the objective methods in ruling out cardiac failure. This negative value of the methods is as important in many respects as their positive value in the diagnosis and study of heart failure, and subsequent clinical developments confirmed the fact that the diagnosis of heart failure was erroneous. Thus, such manifestations as dyspnea, râles at the bases of the lungs, cough, peripheral edema, tachycardia, cardiac enlargement, hypertension, hyperthyroidism, signs of syphilitic heart disease, and signs of rheumatic heart disease may be confusing diagnostically under some conditions. In all of the cases under consideration here, the venous pressure and circulation time measurements were found to be normal.

SUMMARY AND CONCLUSIONS

1. The results of simultaneous measurements of the arm-to-lung and arm-to-tongue circulation times and of the venous pressure in 100 consecutive cases of heart failure are presented.

2. These results show that, in general heart failure, the venous pressure is abnormally elevated or shows a significant rise when the abdomen is compressed, and that the circulation times are usually prolonged. When improvement occurs in this type of heart failure, the arm-to-tongue circulation time may nevertheless remain prolonged for an unpredictable period after all other signs of heart failure have disappeared. This presumably indicates the persistence of left ventricular failure.

3. In seven cases of the series the clinical observations were indicative of isolated left ventricular failure during the entire time the patients were under observation. In these cases the venous pressure and arm-to-lung circulation time were normal, but the arm-to-tongue circulation time was prolonged.

4. In thirty-four cases of general heart failure the lung-to-tongue circulation time was within normal limits. This tends to impair, on theoretical grounds, the value of this measurement in the diagnosis of isolated right ventricular failure.

5. In cases of heart failure, the venous pressure may be abnormally high or rise significantly with abdominal compression when other signs of failure of the right ventricle are lacking.

6. Repeated measurements of the venous pressure and circulation time in cases of heart failure afford a means of following the course of the heart failure objectively.

7. Combined measurements of the venous pressure and circulation time are necessary in cases of heart failure for perfect diagnostic appraisal.

8. When there are symptoms suggestive of heart failure, but none is actually present, the circulation measurements are in many respects as valuable in ruling it out as they are in diagnosing and studying it.

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THE ACTION OF ANGIOTONIN ON THE COMPLETELY ISOLATED MAMMALIAN HEART

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WITH increasing evidence[1-6] that renin is the probable humoral agent in experimental renal hypertension, the action of this substance at any point in the cardio-renal-vascular complex grows in interest.

Hill and Andrus[7] reported a series of experiments in which the effects of renin and angiotonin (activated renin[8]) were studied on cat hearts perfused with Ringer-Locke solution by the Langendorff method. Renin, because of the absence of renin-activator[8, 9] from the perfusion medium, was found to be without effect. Angiotonin, on the other hand, produced a marked reduction in coronary flow, followed often by a late rise. The former effect was undiminished with subsequent injections into the same preparation, whereas the latter was reduced. The amplitude of the beat increased markedly; the change followed that in coronary flow, and often outlasted it. Successive injections showed undiminished effectiveness in this regard. A slight slowing of the heart rate was sometimes noted at the time of the decrease in coronary flow.

The experiments to be reported were undertaken in an effort to examine in greater detail the action of angiotonin on the completely isolated mammalian heart, with particular regard to its effect on cardiac work and efficiency.

METHODS

Six experiments were done on the completely isolated, blood-perfused, cat heart, according to the technique described by Moe and Visscher,[10] but modified for use with smaller mammalians (Fig. 1). Oxygen utilization was measured continuously in a closed system of suitable dimensions and sensitivity. The filling and emptying pressures of the heart were controlled, but the diastolic volume was permitted to decrease with the administration of the angiotonin, for an efficiency increase at a smaller diastolic volume and nearly constant filling pressure is even more significant than an increase of efficiency at higher filling pressures and constant diastolic volume would be.

Six preliminary experiments were done, two with the dog heart-lung preparation, one with the completely isolated dog heart, and three with the completely isolated cat heart. Oxygen utilization and cardiac efficiency were not ascertained in these experiments.

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Received for publication April 28, 1941.

In all experiments on the cat, one animal served as both blood donor and subject. Heparin was used as the anticoagulant. Angiotonin was injected into the perfusion medium in amounts varying from 0.01 to 0.10 c.c.

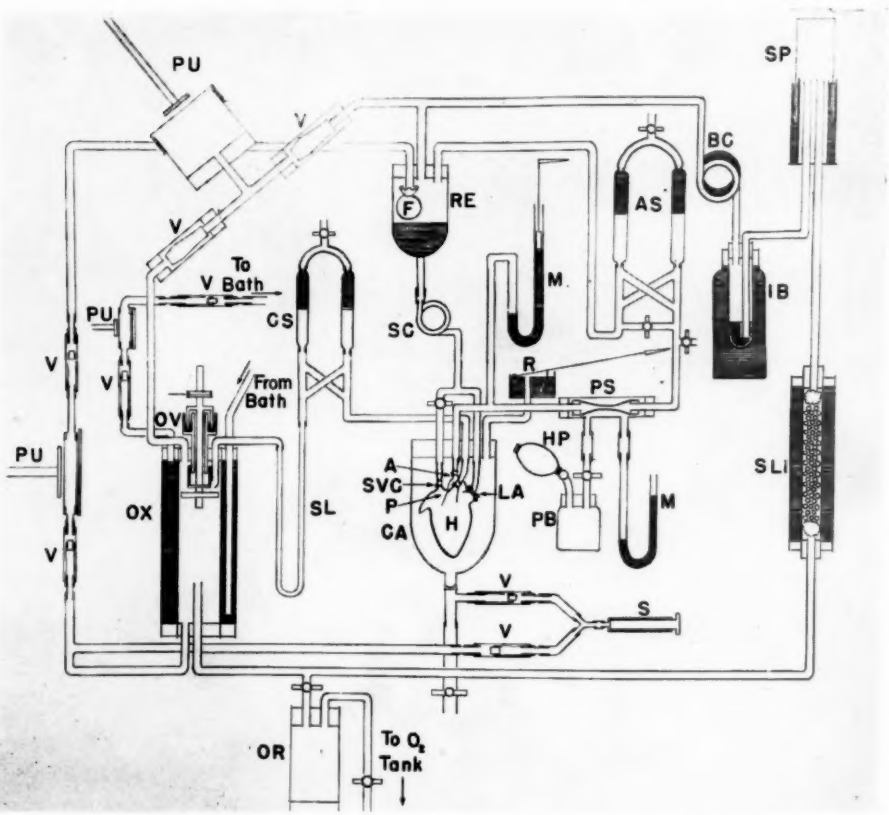

Fig. 1.—*A*, brachiocephalic artery; *AS*, aortic stromuhr; *BC*, brass warming coil; *CA*, cardiometer; *CS*, coronary stromuhr; *F*, filter; *H*, heart; *HP*, hand pump; *IB*, indicator bottle; *LA*, left atrium; *M*, mercury manometer; *OR*, oxygen reservoir for warming O_2 before admitting to the system; *OV*, oil-sealed valve; *OX*, oxygenator; *P*, pulmonary artery; *PU*, pump; *PB*, pressure bottle; *PS*, pressure sleeve; *R*, small spirometer for recording changes in heart size; *RE*, blood reservoir; *S*, syringe for withdrawing drainage fluid and returning to the system; *SC*, silver warming coil; *SL*, silver loop for warming blood entering oxygenator from coronary stromuhr; *SLI*, soda and lime chamber; *SP*, spirometer; *SVC*, superior vena cava; *V*, valve. The cardiometer, pressure sleeve, silver coil, silver loop, brass coil, and oxygen reservoir are immersed in a constant temperature bath. The soda and lime chamber, indicator bottle, and oxygenator are placed in a water jacket. The jacket surrounding the oxygenator is circulated with water from the bath. The diagram is not drawn to scale.

RESULTS

CORONARY FLOW

In the ten isolated heart experiments in which coronary flow was studied, a decrease varying from a small fraction of the total, to complete arrest of flow, in one instance, was noted. In only one case was there no effect (Experiment 11, Table I). In this instance the first two doses were minute (0.01 to 0.02 c.c. of a less active preparation),

but the third was larger (0.10 c.c.). The possibility exists that a transient effect might have occurred between measurements.

TABLE I

THE EFFECT OF ANGIOTONIN ON THE COMPLETELY ISOLATED MAMMALIAN HEART

EXPERIMENT NO.	ANIMAL	DOSE (C.C.)	PER CENT DECREASE IN CORONARY FLOW (MAX.)	DURATION OF CORONARY FLOW EFFECT (MIN.)	PER CENT INCREASE IN CARDIAC WORK (MAX.)	PER CENT INCREASE IN CARDIAC EFFICIENCY (MAX.)	DURATION OF EFFICIENCY EFFECT
7	Cat	0.05	100% attained in 2 min.	3	66% attained in 5 min.	56% attained in 5 min.	Still elevated by 27%, 13 min. following angiotonin
8	Cat	0.05	91% attained in 1 min.	6	73% attained in 6 min.	49% attained in 6 min.	14 min.
9	Cat	0.05	64% attained in 3.5 min.	6	305% attained in 5.5 min.	317% attained in 6 min.	Still elevated by 35%, 22 min. following angiotonin
10	Cat	0.03	71% attained in 1 min.	3	45% attained in 3 min.	44% attained in 3 min.	28 min.
11	Cat	0.01* 0.02*† 0.10*	Decrease not observed		20% attained in 53 min.	15% attained in 53 min.	Still elevated by 11%, 73 min. following angiotonin
13	Cat	0.02	14% attained in 2 min.	9	5.2% attained in 2 min.	5.8% attained in 2 min.	6 min.

*A less active solution of angiotonin used in this experiment.
†A small, transient decrease in diastolic volume observed.

Coronary flow effects appeared quite promptly and lasted only a few minutes. In eleven trials, flow returned to slightly supernormal values in five, slightly subnormal, in four, and to the same level, in two. In one experiment in which three successive trials with the same dose yielded a decrease in flow, this effect diminished progressively.

DIASTOLIC VOLUME EFFECT

In every instance but one, the injection of angiotonin was followed by a fall in diastolic volume which came on promptly and lasted from five minutes to over an hour. Larger doses provoked a response which was greater in both amplitude and duration. When coronary flow restriction was marked, a transient dilatation preceded the diminution in

heart size, or interrupted it momentarily, and coincided with the moment of greatest restriction in coronary flow.

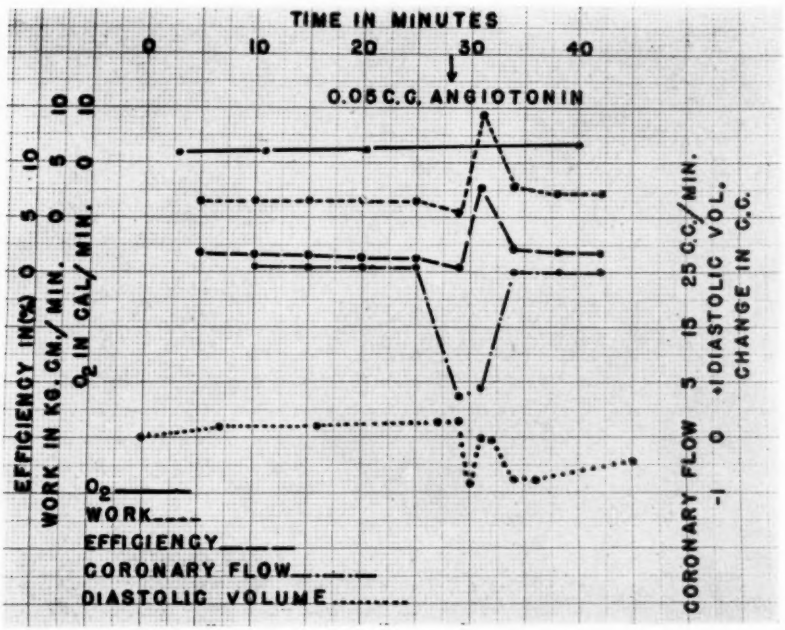

Fig. 2.—Graphic presentation of a typical experiment (Experiment 8, Table I).

The failure to obtain a decrease in diastolic volume occurred in the experiment cited previously (Experiment 11, Table I), and with a dose (0.01 c.c.) that was ineffective in eliciting either an increase in cardiac efficiency or a decrease in coronary flow. In the next trial in the same experiment, a dose (0.02 c.c.) which was incapable of exerting a detectable coronary or efficiency effect did produce a transient decrease in diastolic volume.

CARDIAC WORK, OYXGEN UTILIZATION, AND EFFICIENCY

In the six experiments in which these factors were studied, work was found to increase from 5 to 305 per cent within a few minutes of the administration of angiotonin, and remained elevated from several minutes to over an hour.

In the period after the injection of angiotonin, in all six experiments, it was found that oxygen utilization attained supernormal levels, whereas diastolic volume still remained below the control volume. In spite of this, efficiency increases of considerable magnitude, roughly paralleling those which occurred in work, were noted.

In Experiment 11, Table I, it will be noted that the first two trials did not produce a change in coronary flow, work, or efficiency, and, in

Experiment 13, Table I, the smallest observed decrement in coronary flow (except for Trial 3, Experiment 11, in which no decrease was observed) occurred with the smallest observed increment in work and efficiency.

Too much significance cannot be attached to the occurrence of an efficiency effect in the absence of a decrease in coronary flow, as in Trial 3 of Experiment 11 (Table I). As already stated, it is not impossible that a transient fall in coronary flow might have occurred between readings. It is of interest, however, that in Trial 2 of this same experiment, although no changes in coronary flow, cardiac work, or efficiency were detectable, a transient decrease in diastolic volume was in evidence, indicating some effect on the myocardium.

Table I summarizes the salient features of this group of experiments.

HEART RATE

The usual response was a slight slowing which was coincident with the decrease in coronary flow.

DISCUSSION

Although no exact parallelism between the effects of angiotonin on the coronary vessels and myocardium has been observed with larger doses, both effects decreased in intensity and disappeared as the dosage was diminished. In two cases in which one effect may have been elicited independently of the other, it was the coronary effect that was not observed.

Although one would hesitate to transfer conclusions drawn from experiments of this type to the intact animal, the fact that the vasoconstrictor and efficiency-increasing properties of angiotonin disappear with about the same dose under controlled conditions suggests that, if the substance is liberated in vivo in sufficient quantity to exert one effect, it will probably exert the other, as well.

CONCLUSIONS

Angiotonin, when injected into the completely isolated cat heart, causes (1) constriction of the coronary arteries, (2) a decrease in the diastolic volume of the heart, and (3) an increase in the oxygen consumption, external work, and efficiency of the heart.

The author wishes to thank Dr. Irvine H. Page for suggesting these studies and for furnishing the angiotonin solutions and Dr. M. B. Visscher for his kind interest and help.

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THE AUTONOMIC MECHANISM OF HEAT CONSERVATION AND DISSIPATION

II. Effects of Cooling the Body

A Comparison of Peripheral and Central Vasomotor Responses to Cold

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IN A PREVIOUS communication[1] we reported the effects on skin temperature of exposing the body to heat. Our studies were carried out on patients who had been subjected to various operations on the sympathetic nervous system. The operations were mostly unilateral, and this provided the opportunity for control studies on the normally innervated side. The present report is concerned with the effects on skin temperature of cooling the entire body in a refrigerator.

It might be supposed that under the conditions of these experiments the skin loses heat as an inanimate body. The presence of circulating blood in the skin, however, makes this impossible. The temperature of viable skin at all times is a function of the temperature of the blood and of the factors which control its rate of flow through the cutaneous vessels. To secure data relevant to this problem was the purpose of these experiments.

METHOD

The patient was exposed for twenty to thirty minutes, and basal temperatures of the skin were taken at room temperature. The patient was then placed in a refrigerator* and seated in a chair on a square of blanket, remaining exposed except for a loincloth. The heels of the subject rested on a box, leaving the remainder of the feet exposed. The skin temperatures were followed at intervals, as well as the mouth temperature, blood pressure, and pulse rate. Other observations, such as pilomotor activity, shivering, and the appearance of skin, were recorded.

The skin temperatures were taken with a Tycos dermatherm.† The temperature of the junction thermocouple was checked for each set of readings, and the readings were corrected for any slight change in the temperature of the junction thermocouple. Only the relative changes in skin temperature are recorded in the tables. More patients were studied than are reported here, but these are representative.

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Received for publication Nov. 14, 1940.

*We wish to thank Dr. Elmer DeGowin, of the Department of Medicine, for allowing us the free use of the blood bank refrigerator.

†Taylor Instrument Company, Rochester, N. Y.

The patients reported here did not have vasospastic disorders, except that Buerger's disease (Richard W., Experiment 7) may be associated with an abnormal degree of vasospasm.

Experiment 1.—March 7, 1940. Leah C., aged 33, 379 days after section of the anterior and posterior roots from T 1 to T 5, inclusive, on both sides, and anterior chordotomy at T 3 on both sides, and forty-eight days after removal of the inferior cervical and first dorsal ganglia on the right (Table I).

TABLE I

EFFECT OF LOW TEMPERATURE ON SKIN

PART	SKIN TEMPERATURE (° C.)										
	RIGHT	LEFT		RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT*	LEFT*
Forehead	6.0	6.5		0.5	1.5	−0.5	1.5	−1.5	1.0	−7.5	−5.5
Nose	5.0	5.0		0.0	0.0	−1.0	−1.0	−1.5	−1.5	−6.5	−6.5
Ears	5.0	5.5		1.0	1.5	−1.0	−1.0	−1.5	−1.5	−6.5	−7.0
Cheek	6.0	5.5		1.0	0.0	−0.5	−1.5	−1.5	−2.5	−7.5	−8.0
Neck	7.0	7.0		4.0	4.0	2.5	3.0	1.5	1.5	−5.5	−5.5
Chest	6.5	7.0		2.0	1.5	1.0	0.5	0.0	0.5	−6.5	−7.5
Arm	6.5	6.0		1.5	1.0	0.0	1.5	−2.0	−1.5	−8.5	−7.5
Forearm	6.5	6.0		2.0	1.5	0.0	0.0	−1.0	−1.0	−7.5	−7.0
Palm	6.5	5.5		2.5	0.0	0.0	−2.0	−2.0	−4.0	−8.5	−9.5
Finger	6.0	1.0		1.0	−6.5	−3.5	−9.0	−7.0	(−10.0)	−13.0	(−11.0)
Abdomen	6.0	6.5		1.0	1.0	−0.5	0.0	−1.5	−2.0	−7.5	−8.5
Thigh	5.5	5.0		0.0	−0.5	−1.5	−2.0	−2.0	−2.5	−7.5	−7.5
Calf	4.5	4.5		−1.0	−1.5	−2.0	−3.0	−2.5	−3.5	−7.0	−8.0
Ankle	4.5	5.0		−0.5	0.0	−2.0	−2.0	−3.0	−3.0	−7.5	−8.0
Toe	2.0	2.0		−5.0	−5.0	−8.0	−8.0	−8.5	−8.5	−10.5	−10.5
Mouth temperature	37.22° C. 99.0° F.			37.0° C. 98.7° F.		36.75° C. 98.2° F.		36.40° C. 97.5° F.			
B. P.	180/118			190/130		186/124		190/130			
Pulse rate	72			84		72		84			
Time (P.M.)	3:35		3:45	3:55		4:05		4:15			
Remarks	Basal		Enters refrigerator								

*Last two columns show differences between first and last readings.

( ) The readings in parentheses should be greater (colder), for the needle of the instrument deflected somewhat off the scale.

Room temperature, 23.5° C.; temperature of refrigerator, 5.0° C.

Observations and Comment.—The readings at room temperature showed a significant difference on the two sides only on the palms and fingers; the right (denervated) middle finger was 5° warmer. At the end of the experiment the right finger was 13° cooler, but was still over 3° warmer than the left, which was 11 degrees cooler. The right hand felt subjectively warm throughout the experiment, whereas the left ached with cold. The right (denervated) hand became only slightly flushed, but the normal hand soon became markedly flushed and, later, dusky.

We feel that this experiment is significant only in relation to the cervicodorsal ganglionectomy. The section of the anterior roots from T 1 to T 5 abolished thermoregulatory sweating on the face. However, since the effect was bilateral, it is difficult to draw conclusions from the cold test. The chordotomy did not influence thermoregulatory sweating and hence probably had no effect on the vasomotor responses. The chordotomy on this patient was done by inserting a cataract

knife straight into the cord just anterior to the dentate ligament. The section was about 3 mm. deep and 2.5 mm. wide. The anterior columns and the greater part of the spinothalamic tracts were spared. Motor, bowel, and bladder function and sweating were unimpaired by this procedure. Sensibility to pain and temperature was lost up to a level below the knees. This patient has been reported in another paper.[2]

Experiment 2.—December 3, 1939. Margaret B., aged 31, 351 days after removal of the inferior cervical and upper three dorsal ganglia on the left (Table II).

TABLE II

EFFECT OF LOW TEMPERATURE ON SKIN

PART	SKIN TEMPERATURE (° C.)										
	RIGHT	LEFT		RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT*	LEFT*
Forehead	1.0	1.0		−1.5	−1.5	−4.3	−3.8	−4.3	−3.8	−5.3	−4.8
Cheek	1.0	1.0		−2.5	−1.5	−6.8	−5.8	−6.8	−5.8	−7.8	−6.8
Neck	2.0	2.0		−1.0	0.0	−4.3	−4.3	−4.3	−4.3	−6.3	−6.3
Chest	2.0	2.0		−1.5	−1.5	−5.3	−5.3	−6.3	−5.8	−8.3	−7.8
Arm	1.0	1.5		−1.5	−1.5	−6.3	−4.8	−7.8	−6.8	−8.8	−8.3
Forearm	1.0	1.0		−3.0	−2.5	−6.8	−5.8	−8.8	−5.8	−9.8	−6.8
Finger	−2.0	0.0		−8.5	−6.5	(−11.3)	−11.3	(−11.3)	−11.3	(−9.3)	−11.3
Abdomen	2.0	2.0		−3.0	−3.0	−6.3	−6.3	−7.8	−7.8	−9.8	−9.8
Thigh	0.5	1.5		−4.0	−4.0	−7.3	−7.3	−8.3	−8.8	−8.8	−10.3
Calf	0.0	0.0		−5.5	−5.0	−8.3	−7.8	−9.3	−8.3	−9.3	−8.3
Ankle	−0.5	−0.5		−5.0	−5.0	−7.8	−8.3	−9.8	−9.8	−9.3	−9.3
Mouth temperature	38.0° C. 100.0° F.			38.04° C. 100.1° F.		37.60° C. 99.7° F.		37.0° C. 98.6° F.			
B. P.	116/60			112/64		110/84		110/84			
Pulse rate	116			112		116		108			
Time (P.M.)	2:50		2:59	3:05		3:30		4:00			
Remarks	Basal		Enters refrigerator								

*Last two columns show differences between first and last readings.

( ) The readings in parentheses should be greater (colder) because instrument needle deflected off the scale.

Room temperature, 24.0° C.; temperature of refrigerator, 0° C.

Observations and Comment.—The left (denervated) middle finger was 2° warmer than the right at room temperature. After six minutes in the icebox the left was 6.5° cooler, but was still 2° warmer than the right, the temperature of which had dropped a similar amount. Thereafter, the needle ran off the scale, and accurate readings could not be obtained for the finger. The temperatures of the palms of the hands at the end of the experiment were: right, −10.0; and left, −4.0. Inasmuch as the temperature of the right middle finger deflected the needle off the scale of the instrument, the palm temperatures show more accurately the magnitude of the difference on the two sides. The left arm and left side of the face felt subjectively warm throughout the experiment, whereas the right ached from cold. Shivering did not occur until experiment was nearly completed. At this time, pilomotor activity became evident except in the sympathectomized zone.

Experiment 3.—Jan. 31, 1940. Mabel R., aged 23, 377 days after section of posterior roots C 8 to T 4, inclusive, on both sides, and 328 days after removal of the right inferior cervical and upper two dorsal ganglia (Table III).

TABLE III

EFFECT OF LOW TEMPERATURE ON SKIN

PART	SKIN TEMPERATURE (° C.)										
	RIGHT	LEFT		RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT*	LEFT*
Forehead	2.0	2.0		−1.7	−2.2	−3.4	−2.9	−3.3	−3.3	−5.3	−5.3
Cheek	2.5	2.0		−0.7	−2.7	−1.4	−6.4	−2.8	−7.8	−5.3	−9.8
Nose	0	−1.0		−2.2	−7.2	−3.4	−7.4	−5.3	−9.8	−5.3	−10.8
Ears	0	−0.5		−3.7	−5.2	−4.9	−7.4	−5.3	−7.8	−5.3	−8.3
Neck	3.0	3.0		−0.2	−0.2	−0.9	−0.9	−1.3	−1.8	−4.3	−4.8
Chest	2.0	2.0		−0.2	−0.2	−0.9	−1.4	−1.3	−1.8	−3.3	−3.8
Arm	2.5	2.0		−1.2	−2.2	−3.4	−5.4	−4.3	−6.3	−6.8	−8.3
Forearm	2.5	2.5		−1.7	−1.7	−2.9	−2.9	−3.8	−5.3	−6.3	−7.8
Palm	2.0	−2.0		−2.2	−5.7	−4.9	−7.9	−6.8	−9.3	−8.8	−11.3
Thumb	1.5	−7.0		−5.7	(−10.2)	−8.9	(−10.9)	(−10.9)	(−10.9)	(−12.4)	(−17.9)
Finger	1.0	−7.5		−8.7	(−10.2)	−10.9	(−10.9)	(−10.9)	(−10.9)	(−11.9)	(−18.4)
Mouth temperature	37.04° C. 98.7° F.			36.88° C. 98.4° F.		36.32° C. 97.3° F.		36.77° C. 98.2° F.			
B. P.	128/70			130/88		130/84		120/70			
Pulse rate	60			76		80		64			
Time (P.M.)	4:15		4:25	4:35		4:45		4:55			
Remarks	Basal		Enters refrigerator								

*Last two columns show differences between first and last readings.

( ) The readings in parentheses should be greater (colder) because the needle deflected slightly off the scale.

Room temperature, 22.0° C.; temperature of refrigerator, 6.0° C.

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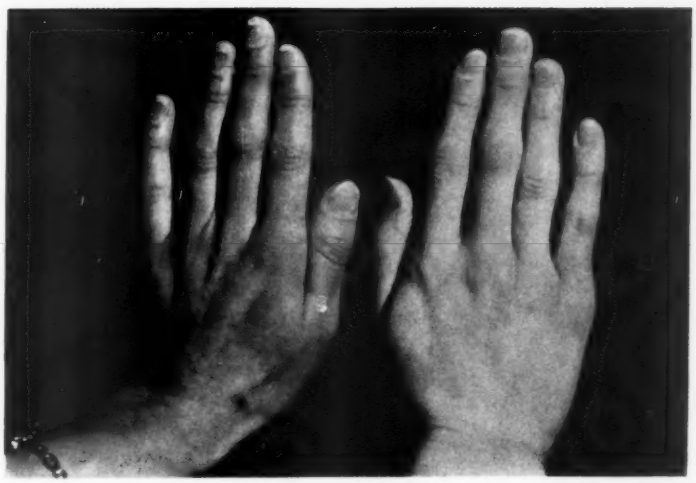

Fig. 1.—The hands of M. R. after being in the refrigerator. The skin of the left (normal) hand is flushed to a much greater degree, and is slightly cyanotic, as compared to the right (sympathectomized) hand.

At the time this photograph was taken the left palm was 2.5° C. colder than the right, but, since the temperature of the right palm had dropped 8.8° C. in the refrigerator, as compared with a drop of 11.3° C. on the left, we do not feel that a terminal difference of 2.5° C. could fully account for the marked difference in appearance of the hands.

Observations and Comment.—We do not feel that section of the posterior roots from C 8 to T 4 had any demonstrable influence on the response to cooling. The patient exhibited pilomotor activity at 4:30, except in the sympathectomized area. After five minutes in the refrigerator there was a great difference in the appearance of the two hands. The right (denervated) hand did not change in color and felt warm, whereas the left became cold, mottled, and cyanotic. This appearance shaded off up to the elbow (See Fig. 1). Subjectively, the right hand felt warm, but the left fingers stung with cold throughout the experiment. The body felt subjectively warmer at 5:30, and shivering ceased. At the termination of the experiment the right hand became slightly flushed also, but not anything like so much as the left.

Experiment 4.—Nov. 25, 1939. Ralph McG., aged 55, 121 days after removal of the inferior cervical and upper six dorsal ganglia on the left (Table IV).

Observations and Comment.—At room temperature the temperature of the middle fingers on the two sides was the same. At the end of the experiment, the left (denervated) middle finger was only 0.5° warmer than the right; its temperature had dropped 10.5°. When the subject entered the refrigerator, a pilomotor reaction was marked over the body except over the sympathectomized zone, and remained so throughout the experiment. At 10:31 he started to shiver. This subsided, but again became extreme at 10:45. He never felt subjectively warm except in the sympathectomized skin zone. The experiment was terminated because the patient was very uncomfortable. His mouth temperature dropped 1.4° F.

Experiment 5.—Dec. 31, 1939. Marlow S., aged 48, nineteen days after splanchnicotomy and removal of the first, second, and third lumbar ganglia on the right (Table V).

Observations and Comment.—He began to feel cold and shivered vigorously in two minutes. At 4:45 he felt warmer and stopped shivering. Pilomotor activity was generalized except over the thigh and leg on the right. At the beginning of the experiment the right (denervated) large toe was 4° warmer than the left. At the end of the experiment the temperature of the right toe had dropped 7.6°, but it was still more than 6° warmer than the left, which was 9.6° cooler. The right (denervated) foot and leg felt subjectively warm throughout the experiment.

Experiment 6.—Feb. 11, 1940. Eline R., aged 39, 510 days after right-sided splanchnicotomy and removal of the right first and second lumbar ganglia, and 455 days after section of anterior and posterior roots T 1 to T 5, inclusive, on both sides (Table VI).

Observations and Comment.—There was marked shivering on entering the refrigerator. At 4:08, pilomotor activity was generalized in the usual areas, except over the right leg. At 4:17, shivering stopped. Throughout the experiment the left foot was definitely more red and dusky than the right. At the beginning of the experiment the right (denervated) large toe was 4.5° warmer than the left. At the end of the experiment the temperature of the right toe had dropped 12.5°, but it was still more than 3° warmer than the left, which had become 11.0° cooler. The right foot and leg felt subjectively warm throughout the experiment.

Experiment 7.—Jan. 1, 1940. Richard W., aged 29, 411 days after removal of the second, third, and fourth lumbar ganglia on both sides (Table VII).

Observations and Comment.—This patient was admitted because of intermittent claudication, and biopsy of a vessel of the leg ultimately proved that he had

TABLE IV

EFFECT OF LOW TEMPERATURE ON SKIN

PART	SKIN TEMPERATURE (° C.)													
	RIGHT	LEFT		RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT*	LEFT*
Forehead	1.5	1.5		−2.4	−1.9	−2.4	−1.9	−3.4	−2.9	−4.0	−2.5	−5.5	−4.0
Cheek	0	0		−1.9	−1.9	−5.4	−3.9	−5.9	−4.9	−6.5	−6.0	−6.5	−6.0
Neck	1.5	2.0		−0.4	−0.4	−2.4	−1.4	−3.4	−2.4	−4.0	−2.0	−5.5	−4.0
Chest	1.5	1.5		−0.4	−0.4	−1.9	−1.9	−2.9	−2.9	−3.5	−3.5	−5.0	−5.0
Arm	1.5	1.5		−0.9	−1.9	−2.4	−2.4	−4.4	−4.9	−4.5	−4.5	−6.0	−6.0
Forearm	1.0	1.0		−1.4	−1.4	−2.4	−2.4	−3.4	−3.4	−4.0	−4.0	−5.0	−5.0
Finger	0	0		−5.9	−4.9	−9.4	−8.4	−10.9	−10.4	−11.0	−10.5	−11.0	−10.5
Abdomen	1.5	1.5		−0.4	−0.4	−1.9	−1.9	−3.4	−3.4	−3.0	−3.0	−4.5	−4.5
Thigh	0.5	0.5		−2.4	−2.4	−2.4	−2.4	−3.4	−3.4	−3.0	−3.5	−3.5	−4.0
Calf	−0.5	−0.5		−1.9	−1.9	−1.9	−2.4	−3.9	−3.9	−4.5	−4.5	−4.0	−4.0
Ankle	−1.0	−1.0		−4.4	−4.4	−5.4	−6.4	−7.4	−7.4	−7.0	−8.0	−6.0	−7.0
Mouth temperature	36.66° C.			36.55° C.		36.06° C.		35.90° C.		35.90° C.			
	98.0° F.			97.8° F.		96.9° F.		96.6° F.		96.6° F.			
B. P.	96/70			110/72				114/76		114/76			
Pulse rate	90			108		104		112		112			
Time	10:20		10:25	10:27		10:35		10:45		10:55			
Remarks	Basal		Enters refrigerator										

*Last two columns show differences between first and last readings.
Room temperature, 27.7° C.; temperature of refrigerator, 0.5° C.

TABLE V

EFFECT OF LOW TEMPERATURE ON SKIN

PART	SKIN TEMPERATURE (° C.)										
	RIGHT	LEFT		RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT*	LEFT*
Forehead	2.0	2.0		−0.3	−0.3	−2.4	−1.4	−3.6	−3.1	−5.6	−5.1
Cheek	2.0	1.0		−2.8	−3.8	−5.9	−5.9	−5.6	−6.1	−7.6	−7.1
Neck	3.0	2.5		−1.8	−0.8	−3.4	−2.4	−2.6	−2.6	−5.6	−5.1
Chest	2.0	2.0		−1.8	−1.8	−3.9	−3.9	−5.1	−5.1	−7.1	−7.1
Arm	1.0	1.0		−2.3	−2.8	−4.4	−4.4	−5.6	−5.6	−6.6	−6.6
Forearm	0.5	1.0		−2.8	−1.8	−4.4	−3.4	−4.6	−4.6	−5.1	−5.6
Palm	0.5	1.0		−2.8	−2.3	−3.9	−3.4	−5.6	−6.1	−6.1	−7.1
Finger	−2.0	−1.5		−8.3	−5.3	−8.4	−8.4	−9.6	−10.6	−7.6	−12.1
Abdomen	1.5	1.5		−2.3	−2.3	−3.9	−3.9	−4.6	−4.6	−6.6	−6.6
Thigh	2.0	1.5		−1.3	−1.8	−2.9	−3.9	−4.1	−4.6	−6.1	−6.1
Calf	1.5	1.5		−1.8	−1.8	−4.4	−4.4	−5.1	−5.1	−6.6	−6.6
Ankle	2.0	1.0		−2.8	−3.3	−4.4	−5.4	−4.6	−6.6	−6.6	−7.6
Toe	3.0	−1.0		−4.3	−8.8	−4.9	(−10.4)	−4.6	(−10.6)	−7.6	(−9.6)
Mouth temperature	37.0° C.			35.75° C.		36.5° C.		36.10° C.			
B. P.	98.6° F.			96.4° F.		97.7° F.		97.0° F.			
Pulse rate	194/150			206/150		220/164		200/150			
Time	100			120		124		120			
Remarks	4:20 (P.M.)		4:30	4:35		4:45		4:55			
	Basal		Enters refrigerator								

*Last two columns show differences between first and last readings.

( ) The readings in parentheses should be greater (colder) because the needle of the instrument deflected somewhat off the scale.

Room temperature, 22.0° C.; temperature of refrigerator, 5.0° C.

TABLE VI

EFFECT OF LOW TEMPERATURE ON SKIN

PART	SKIN TEMPERATURE (° C.)													
	RIGHT	LEFT		RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT*	LEFT*
Forehead	4.0	4.0		−1.5	−1.5	−2.0	−2.0	−4.2	−3.7	−4.5	−3.5	−8.5	−7.5
Cheek	3.5	3.5		−2.5	−2.5	−5.0	−5.5	−6.2	−7.2	−5.5	−6.5	−9.0	−10.0
Nose	1.5	2.0		−6.0	−5.5	−8.0	−8.0	−9.2	−8.7	−8.5	−8.5	−10.0	−10.5
Ears	3.0	3.0		−4.5	−3.5	−8.5	−6.5	−7.7	−8.2	−8.5	−8.0	−11.5	−11.0
Neck	4.0	4.0		−0.5	−1.0	−3.0	−3.0	−3.7	−3.7	−4.0	−4.0	−8.0	−8.0
Chest	4.0	4.0		−2.0	−1.5	−4.0	−4.0	−5.2	−4.7	−5.0	−5.0	−9.0	−9.0
Arm	3.0	3.0		−1.0	−1.5	−5.0	−5.0	−5.7	−5.7	−6.0	−6.0	−9.0	−9.0
Forearm	3.0	2.0		−3.5	−3.5	−6.0	−6.0	−6.7	−7.2	−7.0	−7.0	−10.0	−9.0
Palm	1.5	0.5		−3.0	−3.5	−6.0	−6.5	−7.2	−9.2	−7.5	−8.5	−9.0	−9.0
Thumb	−0.5	−1.5		−8.0	−10.0	(−11.0)	(−11.0)	(−11.2)	(−11.2)	(−11.5)	(−11.5)	(−11.0)	(−11.0)
Finger	−2.5	−3.0		−10.0	(−10.5)	(−11.0)	(−11.0)	(−11.2)	(−11.2)	(−11.5)	(−11.5)	(−9.0)	(−8.5)
Abdomen	2.5	3.0		−4.5	−3.5	−7.0	−6.0	−7.7	−7.2	−8.0	−7.5	−10.5	−10.5
Thigh	2.5	2.5		−3.0	−3.5	−6.0	−6.5	−6.7	−7.2	−7.0	−7.5	−9.5	−9.5
Calf	3.0	3.0		−4.0	−4.0	−7.0	−7.0	−8.7	−8.2	−7.5	−6.5	−10.5	−9.5
Ankle	3.0	1.0		−4.0	−5.0	−5.5	−7.5	−6.2	−8.2	−6.5	−8.5	−9.5	−9.5
Foot	3.5	2.5		−3.0	−3.5	−3.0	−6.5	−6.2	−8.2	−6.0	−8.5	−9.5	−11.0
Large toe	4.0	−0.5		−2.5	−6.5	−5.5	−11.0	−7.2	(−11.2)	−8.5	(−11.5)	−12.5	(−11.0)
Small toe	3.0	−1.5		−5.5	−8.0	(−11.0)	(−11.0)	(−11.2)	(−11.2)	(−11.5)	(−11.5)	(−14.5)	(−12.5)
Mouth temperature	37.08° C. 98.8° F.			37.56° C. 99.6° F.		37.30° C. 99.2° F.		37.30° C. 99.2° F.		37.30° C. 99.2° F.			
B. P.	190/136			240/142		218/118		190/136		194/116			
Pulse rate	66			70		76		80		76			
Time (P.M.)	3:45		4:01	4:10		4:30		4:40		4:50			
Remarks	Basal		Enters refrigerator										

*Last two columns show differences between first and last readings.

( ) The figures in parentheses should be greater (colder) because the instrument needle deflected off the scale.

Room temperature, 22.4° C.; temperature of refrigerator, 4.0° C.

TABLE VII

EFFECT OF LOW TEMPERATURE ON SKIN

PART	SKIN TEMPERATURE (° C.)													
	RIGHT	LEFT		RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT*	LEFT*
Forehead	3.0	3.0		−2.6	−2.1	−5.0	−4.5	−4.5	−3.5	−4.0	−3.5	−7.0	−7.5
Cheek	3.0	3.0		−3.1	−4.1	−5.0	−5.0	−5.5	−6.5	−6.0	−6.5	−9.0	−9.5
Neck	2.5	3.0		−4.1	−3.1	−4.0	−3.5	−4.0	−4.5	−4.0	−4.0	−6.5	−7.0
Chest	2.0	2.0		−5.1	−4.1	−5.0	−5.0	−5.5	−5.5	−6.5	−5.5	−8.5	−7.5
Arm	2.5	2.5		−4.1	−3.6	−5.0	−5.0	−5.5	−6.0	−6.0	−6.0	−8.5	−8.5
Forearm	2.0	2.0		−3.6	−2.6	−4.0	−4.5	−5.0	−4.5	−4.5	−4.5	−6.5	−6.5
Palm	1.0	1.0		−5.1	−4.6	−6.5	−6.0	−8.0	−8.5	−8.5	−9.0	−9.5	−10.0
Finger	0.5	−2.0		−10.1	(−10.6)	(−11.0)	(−11.0)	(−11.5)	(−11.5)	(−12.0)	(−12.0)	(−12.5)	(−10.0)
Abdomen	3.0	3.5		−3.6	−3.1	−4.0	−3.5	−5.5	−4.5	−4.5	−4.5	−7.5	−7.5
Thigh	1.0	1.5		−3.6	−3.1	−4.5	−4.0	−4.5	−5.0	−4.5	−5.0	−5.5	−6.5
Calf	2.5	2.0		−3.6	−4.1	−5.0	−5.5	−5.5	−6.0	−5.5	−5.5	−8.0	−7.5
Ankle	2.5	2.5		−4.6	−4.6	−6.0	−6.5	−6.5	−7.0	−7.0	−7.0	−9.5	−9.5
Toe	3.0	3.0		−4.6	−4.6	−5.5	−5.0	−6.5	−6.0	−7.0	−6.5	−10.0	−9.5
Mouth temperature	36.88° C. 98.4° F.			36.10° C. 97.0° F.		36.10° C. 97.0° F.		36.10° C. 97.0° F.		36.10° C. 97.0° F.			
B. P.	130/100			140/105		160/110		144/110		136/100			
Pulse rate	96			92		84		88		88			
Time (P.M.)	1:45		1:55	2:05		2:15		2:30		2:40			
Remarks	Basal		Enters refrigerator										

*Last two columns show differences between first and last readings.

( ) The figures in parentheses should be greater (colder) because the instrument needle deflected off the scale.

Room temperature, 22.0° C.; temperature of refrigerator, 4.0° C.

Buerger's disease, although there were no trophic changes. The temperatures of the large toes were equal at the beginning of the experiment, and only 0.5° different at the end; that of the right had dropped 10°. His feet felt subjectively warm throughout the experiment, "like they were in an oven," but his hands ached with cold and felt frozen. His toes were warmer than his fingers at room temperature.*

He felt cold on entering the refrigerator, and his legs shivered some. At 2:05 there was general shivering, and pilomotor activity was generalized except over the legs and feet. At 2:15 he stopped shivering and felt warmer. At 2:30 he started shivering again.

DISCUSSION

Influence of Sympathectomy on Response of Arterioles to Cold.—Several outstanding facts are demonstrated by these experiments. When the nude subject is exposed to an environment of 0° to 5° C., the temperature of the skin falls rapidly. The hands, fingers, feet, and toes show the greatest fall (10° to 18°). The temperature of a sympathectomized finger or toe may drop 10° or 15°, but, in all except one patient, the finger remained 3° to 6° warmer than its normal mate.† This patient (Ralph McG., Experiment 4) was the only one in the group the temperature of whose fingers was not materially changed by cervicodorsal ganglionectomy. In his case, at the end of the cold test the fingers on the two sides had cooled to practically the same degree. We have pointed out in a previous publication[1] that, in our experience, the central sympathetic vasomotor control of the hands and fingers diminishes with age, and, in persons past 50 without vasospastic disease, we have usually found little or no change in finger temperature after cervicodorsal ganglionectomy. After unilateral cervicodorsal ganglionectomy which was recently done on two elderly patients, a man of 67 and a woman of 80, the sympathectomized fingers did not become warmer. In our experience, the toes have always become warmer after lumbar ganglionectomy, regardless of age.

The refrigerator experiment demonstrates the magnitude of the reaction of the vessels (arterioles) themselves to cold (first order reaction).‡ No doubt, if the extremities of these patients had remained outside the refrigerator and had been independently exposed to room temperature, the sympathectomized hand or foot would not have changed its tempera-

*Sixteen suitable persons were exposed to room temperature in the nude for thirty minutes. The skin temperatures of the large toes and middle fingers of each were taken. The large toe was colder than the middle finger in every case. The averages were as follows:

	RIGHT	LEFT
Large toe	4.0	3.8
Middle finger	7.6	7.6

Hence, the toes in these subjects were 3.6° to 3.8° colder than the fingers. This offers some basis for comparison.

†These results are in keeping with those of Lewis and Landis.[3]

‡We refer to the response of the vessel itself, without central connections, as a reaction of the first order. A response contingent upon reflexes through the cord is a reaction of the second order. A response contingent upon impulses from the hypothalamus is a reaction of the third order.

ture substantially, but, in our experiments, the part itself was exposed to the same temperature as the remainder of the body. In a recent report[1] we emphasized this point in relation to the heat test, and in comparing our results with those of Lewis and Pickering.[4]

In the refrigerator experiment we are measuring on the sympathectomized side the capacity of the denervated arterioles to respond to cold, whereas, on the normal side, we are measuring the same thing plus a superimposed vasoconstriction due to activity of the central (third order) (and second order?) mechanisms. The magnitude of the *first order* reaction is remarkable.

Thus we have a quantitative method of ascertaining the magnitude of the role played by the central vasomotor governor when the body is exposed to severe cold. The mechanism is more active in young persons, and may be entirely absent in the hands of aged persons. This is probably one of the reasons why heat conservation becomes less adequate with age.

In young persons the mouth temperature usually drops 1° or 2° after five or ten minutes in the refrigerator. At this time there is a subjective feeling of cold. Shivering* occurs for five or ten minutes, and then may cease, after which the mouth temperature begins to rise and the patient has a subjective feeling of warmth.

Influence of Sympathectomy on Pain Incident to Cold.—Although the sympathectomized side objectively becomes quite cold in the refrigerator, the patient has the feeling that it is "warm as toast," as compared to the normal side, which aches and stings with cold. This is true of not only the digits, but also of the entire sympathectomized zone. When our subjects were exposed in the refrigerator the normal hand shortly began to sting and ache, and subjectively was decidedly cold. In no case did these sensations occur in the sympathectomized hand or foot. In all of our subjects the sympathectomized hand felt comfortable and devoid of pain, even at a time when it was objectively as cold or colder than was the normal hand, which had begun to sting and ache. Under the conditions of these experiments, when only a unilateral cervicodorsal ganglionectomy has been done, we are forced to conclude that the pain incident to cold is materially influenced by the sympathetic system. Whether this type of pain is mediated by afferent sympathetic fibers or whether the elimination of efferent sympathetic fibers raises the threshold of somatic stimulability is debatable, and remains to be proved. Vasoconstriction undoubtedly initiates the pain impulses in question.

*We had occasion to test one patient who had had a bilateral chordotomy at C 8. The cataract knife had been inserted about 1 to 2 mm. anterior to the dentate ligament, and was brought out at the anterior median fissure, thus interrupting the spinothalamic tracts and anterior columns. This patient shivered most vigorously above the nipples. There was not a solitary shiver below this level. The phenomenon was so definite that there can be no question that the neural mechanism for shivering had been interrupted. His pyramidal tracts were intact. Sweating and control of the bowels and bladder were unimpaired. There was loss of sensibility for pain and temperature below the nipples.

We have had some patients with unilateral cervicodorsal ganglionectomy clutch a block of ice in each hand. We used blocks one-half the size of an ordinary refrigerator ice cube. One patient (Margaret B., Experiment 2) was compelled to drop the ice from the normal hand in twenty seconds, but she retained the ice in the sympathectomized hand, without discomfort, until it melted. Another patient was compelled, because of pain, to drop the ice from the normal hand in fifteen seconds, but retained the ice in the sympathectomized hand, without discomfort, for two minutes. In these cases there was no demonstrable diminution in the normal ability to discriminate differences in temperature on the sympathectomized side. The ability to discriminate differences and changes in temperature is a function of somatic afferent nerves. Only pain which is incident to vasoconstriction is modified in some way by the sympathetic system. When the patient compares the sensation from a sympathectomized skin zone to that from a normal zone, and when both are subjected to the same cold environment, the sensations of temperature are distinctly different. Subjectively, the sympathectomized zone feels much warmer.

Richard W. (Experiment 7) had Buerger's disease, with intermittent claudication. He had had a bilateral lumbar ganglionectomy. When in the refrigerator he stated that his feet felt as if they were in an oven, while his hands ached and felt frozen. The same reasoning already given concerning the mediation of pain from vasoconstriction in the upper extremities applies to the lower extremities also.

We have recently made more detailed studies concerning the influence of the sympathetics on pain incident to cold, and on the comparative interpretation of temperature.[5] The benefit derived from sympathectomy in the treatment of Raynaud's disease can undoubtedly be attributed, in part, to elimination of the pain of vasoconstriction herein described. Further evidence in support of this statement has been obtained and will be submitted for publication.

Influence of the Sympathetics on Capillary Dilatation in the Hands Caused by Exposure of the Entire Body to Cold.—At the end of a refrigerator experiment a sympathectomized hand or foot will, at most, have become only slightly flushed (first order capillary dilatation). The normal hand, however, becomes flushed early, and later may present a dusky, slightly cyanotic hue. This capillary dilatation probably serves to protect the skin, and is largely under the control of the central mechanism. The late cyanotic hue is due to the great retardation in the velocity of capillary blood caused by arteriolar constriction. Capillary dilatation following the stimulus of cold is partly a peripheral (first order) response and partly a central (third order) (and second order?) response, and is normally, a combination of the three. After unilateral cervicodorsal ganglionectomy, a small block of ice on the forearm or hand will produce the same phenomenon, and to the same degree, on the nor-

mal and sympathectomized sides. The first effect is pallor. This is followed shortly by reddening limited to the area of application. When the ice is removed, the flush persists for some time. This is a local (first order) reaction. If the patient is taken into a refrigerator (0° to 5° C.), so that the entire body is exposed to cold, the first order reaction will be markedly re-enforced in the normal hand.* The normal hand will become quite flushed, and later may present a cyanotic hue, but the sympathectomized hand will become only slightly flushed (see Fig. 1).

The flushing after local application of cold which was studied by Lewis[6] is a local reaction of the first order. His supplementary studies[7] would involve first (and second?) and third order responses. Lewis found that the local reaction did not occur, as is also true of the histamine flare, after degeneration of peripheral nerves. The reaction was not abolished by degeneration of sympathetic nerves only. Lewis therefore attributed the reaction to an axon reflex. Inasmuch as this first order response is not influenced by degeneration of sympathetic nerves, we must have witnessed the first order response in the sympathectomized hand in pure form, and as a local response to cold. The increased and marked capillary dilatation in the normal hand in response to severe cold is strong comparative evidence that there is a central control of capillary dilatation.

Cold did not cause the unilateral flushing of the face which was brought about by exposure to heat.[1] In the refrigerator the phenomenon was limited to the hands.

A Dual Mechanism of Capillary Responses.—We have presented evidence that there is a central control of capillary dilatation in response to both extreme heat[1] and severe cold. The control is mediated through the thoracolumbar sympathetic system. This control is abolished by sympathectomy, but there still remains a local (first order) response.† Lewis[6] has shown that this local response is not abolished by degeneration of sympathetic fibers, but is abolished by degeneration of somatic sensory nerves. The first order response appears to be comparable in all respects to the histamine flare, and hence must be governed by an axon reflex mechanism. Therefore, it may well be that the first order mechanism to which we have referred is governed by an axon reflex, and hence is related to the somatic sensory nerves. That mechanism is distinctly different from the one related to the sympathetic system.

Skin arterioles are controlled by at least a dual mechanism, peripheral and central. We shall disregard for the present any possible role that reflexes through the spinal cord may play.‡ The peripheral mechanism

*In the refrigerator the normal hand becomes objectively colder than the sympathectomized hand, in spite of the greater capillary flushing.

†By first order response we do not imply that the vessel in question is necessarily devoid of nerve fibers, but only that it is devoid of central connections.

‡To obtain conclusive evidence that there are cord reflexes (second order mechanism), we feel that one should carry out studies on the spinal animal or spinal man. Sahs and Fulton[8] have adduced definite evidence of this reflex in spinal monkeys.

of dilatation or constriction of arterioles is contingent upon an inherent reactivity to changes in temperature.* This reactivity is of great importance and of considerable magnitude when compared to the effects of the central (hypothalamic) mechanism. The peripheral, or first order, mechanism is not an integrated one, but reacts quickly to changes in temperature without requiring a change in the temperature of the blood which circulates through the hypothalamus. Hence, if only a portion of the skin surface is exposed to cold, there is a local adjustment of vessel caliber to meet the issue, exclusive of central reflexes. On the other hand, if the change in environmental temperature or the area of skin exposed is sufficient to warm or cool the blood which circulates through the hypothalamus, the central, or third order, mechanism will function, and will utilize the entire skin surface as an integrated unit in the endeavor to restore and maintain a constant, normal, central temperature. The central mechanism also has other means at its disposal, aside from vasomotor control, i.e., sudomotor and pilomotor activity and shivering.

Sudomotor, vasomotor, and pilomotor activity and shivering vary in their relative magnitudes from person to person and with age. If we take the temperature range from 0° to 48° C., at any given temperature in this range the degree of vasoconstriction in the skin of the fingers will depend on the tone inherent in the vessel, plus the degree of vasoconstriction imposed by the sympathetic mechanism. At 35.5° C. (78.0° F.), which is ordinarily regarded as room temperature, the magnitude of this latter factor will vary with different persons and with age. We believe that it is usually greater for the toes than for the fingers.

We have found that, after a unilateral cervicodorsal ganglionectomy, the difference in temperature of the fingers on the two sides will vary from time to time, even when the nude body is always exposed to the same environmental temperature. We have found that this difference varies from 0° to 6° or 7° C.; it is probably contingent upon variations in the psychic and physiologic state that the organism normally undergoes. The psychologic reactions to pain incident to a hypodermic injection or the insertion of a needle into a vein may cause definite changes in the skin temperature of the normal hand.

It is a strange fact that both peripheral and central vascular responses are outstandingly greater for the skin of the carpal and pedal extremities and digits than for the remainder of the skin of the body of man. We believe that this phenomenon is more of physiologic and evolutional,

*Ascroft[9] performed some interesting experiments on monkeys after unilateral cervicodorsal ganglionectomy. The monkeys were placed in a cabinet the temperature of which was kept constant, or so adjusted as to attempt to keep the rectal temperature constant. The hands were outside the cabinet and the outside temperature was changed. Ascroft concluded that after degeneration occurred following cervicodorsal ganglionectomy, the response was much greater to cold than after preganglionic sympathectomy, and hence, after degeneration, the vessels of the skin acquire a greater restoration of inherent tone. If this be consistently true, this factor for the upper extremities would have to be given an importance at least equal to that of circulating adrenaline. We found in our refrigerator experiments, however, that the fall in the temperature of the sympathectomized toes of man (preganglionic) was of the same magnitude as that of the fingers after degeneration (postganglionic) had occurred. These results would not bear out Ascroft's hypothesis.

than of anatomic, significance. Judging from our experience, the vessels of the ear of man are not comparable to those of the ear of the rabbit in their response to sympathectomy. For example, we have found little or no difference in the temperature of the two ears of man after unilateral cervicodorsal ganglionectomy, whereas, in the rabbit, vasodilatation of the sympathectomized ear is marked.

Both the systolic and diastolic blood pressures were somewhat elevated during the experiment, and substantially so in the two cases of hypertension (Experiments 1 and 6). There was usually a moderate increase in pulse rate.

CONCLUSIONS

1. If a nude subject goes from a room at ordinary temperature to one at 0° to 5° C., the skin temperature will drop markedly and rapidly; the hands, fingers, feet, and toes exhibit the most marked change.

2. The central temperature may fall 1° or 2°, followed by shivering. In a young person the central temperature may rise again, shivering will cease for a time, and he will have a subjective feeling of warmth.

3. If one extremity is sympathectomized, exposure in a refrigerator provides a quantitative measure of the peripheral (first order) response to cold on the denervated side, and of the central (third order) (and second order?) response to cold, in addition to the peripheral response, on the normal side.

4. A hand that becomes warmer after cervicodorsal ganglionectomy will remain substantially warmer than its normal mate in a cold environment, although both show evidence of marked arteriolar constriction.

5. A hand that does not become warmer after cervicodorsal ganglionectomy (usually persons over 50) will exhibit the same fall in temperature as its mate in a cold environment, and the temperatures of the hands and fingers will remain equal.

6. Capillary dilatation in response to cold is partly under central control and is probably a protective mechanism.

7. Evidence was obtained which indicates that the pain incident to cold (vasoconstriction) is markedly reduced by sympathectomy. We do not feel that the vasodilatation usually incident to sympathectomy adequately or fully accounts for the altered sensation.

8. The results of the refrigerator experiments indicate the importance and magnitude of the peripheral (first order) vascular response to changes in temperature. They further suggest that the central (third order) mechanism is of importance in extreme changes and in the utilization of the entire skin surface as an integrated unit for heat conservation.

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AN ELECTROCARDIOGRAPHIC STUDY OF THE EFFECTS OF BOXING

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THE etiological relationship of organic heart disease to nonpenetrating trauma of the chest wall is of considerable present-day interest. Although there is no question as to the effect of trauma on the heart in animals, as shown by the work of Kahn and Kahn,[1] Beck,[2] Kissane,[3] and others,[4] no comparable electrocardiographic study in man has been reported, except in a few cases of accidental trauma.

Because there are severe chest blows in strenuous bouts of boxing, it was thought that electrocardiographic study before and after such bouts might indicate evidence of organic damage of the heart. Through the courtesy of the *New York Daily News*, Dr. Irving S. Cutter, and Dr. Henry Blum, we were able to study a group of boys in the annual Golden Gloves Boxing Tournament.

Electrocardiograms† of thirty-five boys in the weight classes from 112 pounds to heavyweight were taken before and after each bout. Each match consisted of three rounds of two minutes each, unless stopped sooner by a knockout. All electrocardiograms were taken shortly before and as soon after each bout as was possible and when the subject was in the sitting position. A Cambridge "Simplitrol" portable string galvanometer was used in each case. Three standard leads and three chest leads were recorded before and after each contestant's bout. The chest leads were CF_1, CF_2, and CF_4, according to the nomenclature recommended by the American Heart Association.[5]

These boys, whose ages ranged from 16 to 24 years, had previously had one or more negative physical examinations, and most of them were in fair condition, although a few were noticeably in poor shape as far as training was concerned. These matches are well known for the keen competition and fast fighting, and many knockouts occurred. Unfortunately, we did not have the opportunity to do complete cardiac examinations on these boys, nor were we able to make a follow-up study at a later date.

Table I gives the average values of the electrocardiographic deflections in the thirty-five cases. In the standard leads 1 millivolt was represented by a string deflection of 1 cm., and, in the precordial leads, by a deflection of 0.5 cm.

Rate.—Before the bouts the average heart rate was 81 beats per minute; there were one case of bradycardia (50 beats per minute) and three of tachycardia (105, 108, and 110 beats per minute). In every

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Received for publication March 10, 1941.

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†We are indebted to Dr. P. K. Boyer, Dr. Maurice Chassin, and Dr. Allen Tanney for aid in taking the electrocardiograms.

TABLE I

	BEFORE EXERCISE			AFTER EXERCISE		
	MINIMUM (MM.)	MAXIMUM (MM.)	MEAN (MM.)	MINIMUM (MM.)	MAXIMUM (MM.)	MEAN (MM.)
P_1	0	2	0.79	0	1.5	0.78
P_2	1	3	1.6	1	4	2.3
P_3	0	2.5	0.96	0	3.5	1.6
Q_1	0	1.5	0.13	0	1	0.06
Q_2	0	2	0.26	0	4	0.59
Q_3	0	7	0.84	0	7	1.1
$Q\text{-}CF_1$	0	2	Only 1 case	0	5	Only 1 case
$Q\text{-}CF_2$	0	12	Only 1 case	0	10	Only 1 case
$Q\text{-}CF_4$	0	1	Only 1 case	0	0	0
R_1	3	18	8.4	3	15	7.4
R_2	9	22	15.7	10	25	16.0
R_3	1	24	10.0	1	24	12.6
$R\text{-}CF_1$	0	6	3.0	0	7	3.0
$R\text{-}CF_2$	0	14	5.3	0	11	5.5
$R\text{-}CF_4$	4	20	13.2	2	22	9.8
S_1	0	10	3.1	0	10	3.6
S_2	0	6	1.9	0	6	1.9
S_3	0	10	1.1	0	11	0.9
$S\text{-}CF_1$	0	12	7.0	0	14	7.4
$S\text{-}CF_2$	0	22	11.5	0	18	11.6
$S\text{-}CF_4$	0	20	8.7	3	20	10.0
T_1	1	6	2.7	1	4.5	2.2
T_2	−1	4.5	2.4	1	4	2.0
T_3	−2	2.5	−0.27	−2.5	1	−0.54
$T\text{-}CF_1$	0	2	1.22	0	3	1.43
$T\text{-}CF_2$	1	8	3.29	1.5	7	3.36
$T\text{-}CF_4$	1	6	3.21	2	7	3.47
Axis	0°	125°	+66.9°	−12°	+128°	±7.4° 74

case the rate was faster after the bout (average 115 beats per minute) than before. Sinus arrhythmia was common before the matches, but was absent or slight at the higher rates after the matches.

P-R Interval.—The P-R interval varied from 0.12 to 0.17 second, but in individual cases there was almost no change after exercise. The average value was 0.149 second.

QRS Time.—The values varied from 0.06 to 0.09 second, with no change in individual cases before and after the matches. The average value for the seventy tracings was 0.074 second.

Q-T Interval.—In many cases there was no change in the Q-T interval, but with marked increases in rate following exercise the Q-T interval tended to decrease. The average value before the matches was 0.306 second, and after, 0.326 second. No corrections were made for changes in rate.

P Waves.—There was a marked change in the height of the P waves in Leads II and III, in which, in almost every case, there was a peaking after exercise; the average values increased 0.7 mm. in Lead II and 0.66 mm. in Lead III after exercise. These figures were treated sta-

tistically, and the changes were found to be significant. No notching of consequence was present in any of the records.

Q Waves.—In only six of the seventy records were Q_1 waves present, and these were only 1 mm. in five cases and 1.5 mm. in the sixth case.

Seventeen (24.3 per cent) of the tracings had Q_2 waves; the largest was 4 mm., and, in this case, Q_3 was 7 mm. (see below).

Q_3 was more common; it was present in thirty-four (48.6 per cent) of the seventy electrocardiograms. The largest value was 7 mm., and, in this case, it was slightly over one-fourth of the major deflection in any lead. All other Q_3 deflections were less than one-fourth of the major deflection. Exercise had practically no effect on the size of the Q waves.

Only three (4.3 per cent) of the tracings showed Q waves in any of the precordial leads, and only one of these (1 mm.) was in Lead CF_4.

R Waves.—The average values of the R deflections may be seen in Table I. There was a slight tendency for R_1 to decrease in amplitude following exercise, and for R_3 to increase. R in CF_4 also decreased after exercise.

S Waves.—The S deflections showed a tendency opposite to that of R; they increased slightly in Leads I and CF_4 after exercise, and decreased in Lead III.

T Waves.—There were no negative T waves in Lead I, and only one in Lead II, after exercise, whereas T_3 was negative in forty (55.5 per cent) and diphasic in eight (11.4 per cent) of the seventy tracings. A reversal of sign of the T_3 wave after exercise occurred in four cases; it changed from positive to negative in three cases, and from negative to positive in one case. Three instances of a diphasic T were found in the precordial leads, but none of these were in Lead CF_4. In general, the T waves in the standard leads decreased in amplitude after exercise, whereas in the precordial leads they increased slightly in amplitude.

U Wave.—Nineteen of the electrocardiograms showed definite U waves, and all occurred before exercise when the rate was low. U waves were probably present in other cases, but, because of low amplitude and interference, they were not discernible.

Axis Deviation.—One subject had an axis of less than 0° (left), and in five cases it was more than 90° (right). The average axis before exercise was 66.9°, and, after exercise, 74.4°. Twenty-four subjects showed an increasing left axis (average 13°) after exercise, and nine showed a decreasing left axis (average −8.1°) following exercise. Four of these nine subjects were in the right axis range (over 90°) before exercise.

QRS Complex.—Minor degrees of slurring and splitting of this group were common in all leads, but were most pronounced in Leads III, CF_1, and CF_2. There were no definite changes following exercise.

S-T Segment.—In the three standard leads the S-T segment was isoelectric in all cases, but slight elevations, never exceeding 1 mm., were common in the precordial leads, particularly in Lead CF_2, in which lead twenty-two of the tracings showed elevations of 1 mm.

Extrasystoles.—Ventricular extrasystoles were present in only one case, and occurred in this boy following his bout. No auricular extrasystoles were found.

DISCUSSION

From this study we have no evidence that trauma of this nature to the chest wall causes any changes in the heart except in Case A21, in which there was inversion of T_2 and T_3 following exercise, and in Case B14, in which ventricular extrasystoles appeared after exercise. These are nonspecific changes, however, and might be due to any one of a number of causes. Different results might be expected if a similar study were made on a group of older men, for age changes and arteriosclerosis might be present and act as a predisposing factor to injury from indirect trauma. It is usually in these later age groups that such injury occurs.

The average values of the various deflections in the electrocardiograms correspond fairly well with those given in the literature for similar groups. Naturally, there are minor differences due to the position of the subject, emotional stress, and such factors. It has been of great interest to us to note the diversity of the tracings in a group of normals. We feel that it would be wise for anyone who is doing routine electrocardiographic interpretation to study such a group carefully in order to refrain from reading too much into routine tracings.

The changes after exercise were of considerable interest. There was an almost universal increase in the height of P_2 and P_3, with a tendency to sharpening and pointing of the waves. Whether this was due simply to an increase in rate or to actual increase in intra-auricular pressure cannot be ascertained.

There was also a definite decrease in the height of the T waves in the standard leads following exercise, with an increase in the T waves of the precordial leads. This is in disagreement with the work of Barker, Schrader, and Ronzoni,[6] who studied four normal subjects before and after exercise and concluded that "exercise is followed by acidosis and by a striking increase in the amplitude of the T waves."

Pudda[7] reported only slight changes in the standard leads after exercise, and Jaffe[8] noted an increase in "the angle alpha" for P and T waves after exercises.

Our results are in agreement with those of Barker, Schrader, and Ronzoni as far as T_3 is concerned, for it became increasingly negative after exercise. Some of these discrepancies may be explained by differ-

ences in the interval which elapsed between cessation of the exercise and taking of the tracings.

SUMMARY

1. Electrocardiograms of thirty-five young boxers were taken before and after matches.

2. Following exercise there were a definite increase in the height of P_2 and P_3 and a decrease in the size of the T waves.

3. There is no evidence from this study that boxing has any traumatic effect on the normal heart in this age group.

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THE RECORDING OF THE FETAL ELECTROCARDIOGRAM

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THE possibility of making a reliable graphic record of the fetal heart beat has interested both the cardiologist and the gynecologist for a long time. Such a record would be of great value to the gynecologist for practical clinical use, and to the clinical investigator as a new method of approach to certain problems in fetal physiology.

In the past the electrocardiograph has been used extensively in this study. In addition to the three customary leads, abdominal, vaginal, and rectal leads have been tried, but none of these have met with much success. Hoff, et al.,[1] in a recent paper, reviewed the earlier literature on this subject. They pointed out that the main difficulty has been the low electromotive force of the fetal heart, resulting in small fetal waves which are easily obscured when superimposed on the small irregularities in the electrocardiographic record.

Most of the published curves showing the fetal waves which were obtained with the customary electrocardiograph are, on the whole, not convincing, although during the last several weeks of pregnancy a good degree of success was obtained.[2] Occasionally the fetal electrocardiogram is recorded by accident.[3]

A new and much more successful approach, of which we were unaware at the time we began our work, was made by Bell,[4] who used a modified balanced-input, amplifier system of Matthews. He obtained records with abdominal leads from thirty-three pregnant women within two months of term, of which ten were "positive," eleven were "doubtful" and twelve were "negative." Two additional records, taken at four and 4.5 months of pregnancy, did not show fetal waves. The earliest positive record was taken thirty-four days before delivery. In one of two cases of twin fetuses a double set of fetal waves was recorded.

Having available a more sensitive apparatus, we undertook a study of the fetal electrocardiogram throughout pregnancy.

METHOD

Recordings were made with a 3-channel, balanced amplifier and crystograph,* an instrument developed to record electroencephalograms. Time constants of "0.2" for low frequencies and "3" for high frequencies were effective if potential

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This work was aided by the John and Mary R. Markle Foundation through a grant with which the electroencephalograph was obtained for the Department of Anatomy.

Received for publication May 8, 1941.

*Offner amplifiers, numbers 140 and 340; and Offner crystograph, 500A.

changes associated with respiration, etc., were not too prominent. In the latter instance a time constant of "0.02" and, at times, "0.002," was used for damping low frequencies (mechanical damping of the vibrations of the writing pen by pressure was necessary in order to make this effective). Leads were taken from the abdomen with the nonpolarizing suction electrodes described by Andrews,[5] or by means of flat metal discs in electrode jelly, held in place by adhesive tape. We found the latter type somewhat more satisfactory. The ground electrode was placed on the lower part of the left thigh. Three abdominal leads were usually used, and were placed to form an equilateral triangle over the uterus. The size of the triangle depended on the height of the fundus because the midline electrode was placed at approximately the level of the top of the fundus. The other two were placed over the right and left lower quadrants of the abdomen. Tracings were taken from all combinations of these four leads, and three different leads were recorded simultaneously. The curves were recorded by the crystograph on paper, with ink, making a permanent record. No developing is necessary, as with the usual type of electrocardiogram.

Deflections caused by the maternal heart beat were always recorded from pairs of the three abdominal leads, and usually from these in combination with the ground lead. Deflections produced by the fetal heart beat were clearly recognizable in a large percentage of the cases. Increasing the amplification of the potentials in questionable cases was effective in spite of the accompanying amplification of artifacts. This was true especially when the time constant for the low frequencies was reduced, and the writing arms were mechanically damped.

We calculated the length of pregnancy by assuming that conception occurred fourteen days after the beginning of the last normal menstrual flow.

RESULTS

Several kinds of waves are ordinarily recorded in tracings obtained from the abdomen. Most prominent are the deflections caused by the maternal heart beat. These vary in size, but usually have an average deflection of about 200 microvolts.* The fetal deflections are usually much smaller, and measure about 30 microvolts. In addition, there are often many irregular, small waves of varying size. The exact origin of these is not clear at present. The fetal waves usually appear in one lead, and frequently in several leads.

We have taken forty-six records at various stages of pregnancy (Fig. 1). In thirty-one of these, deflections produced by the fetal heart beat were clearly present, and these records were graded as positive (67 per cent). The remainder showed no definite fetal deflections, and were therefore negative, except one which was questionable.

It will be seen from Fig. 1 that no positive tracing was obtained earlier than the sixteenth week of pregnancy, and that there is a sharp dividing line between the positive and negative records near the end of the fourth month. From the sixteenth week onward there were thirty-eight records. Thirty-one of these were positive (82 per cent). Photographs of sample records, showing positive curves during

*Deflections of the ordinary string galvanometer electrocardiogram are about 2 to 3 millivolts for an adult heart. One millivolt equals 1,000 microvolts.

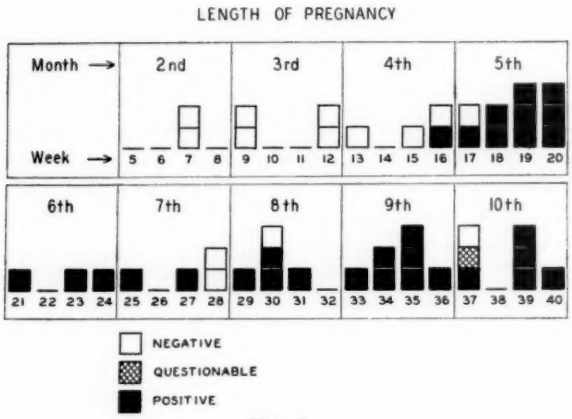

Fig. 1.

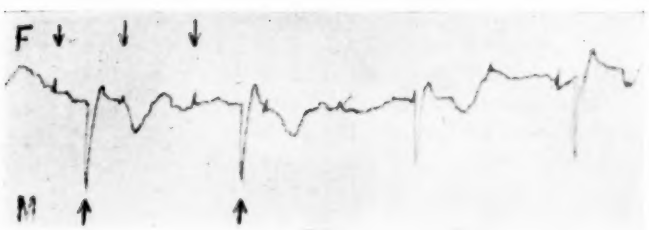

Fig. 2.—Seventeenth week of pregnancy. Heart rates: fetal, 152; maternal, 69.

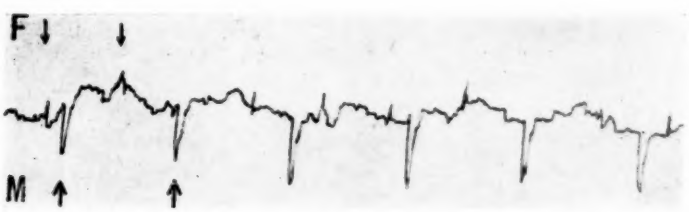

Fig. 3.—Eighteenth week of pregnancy. Heart rates: fetal, 150; maternal, 91.

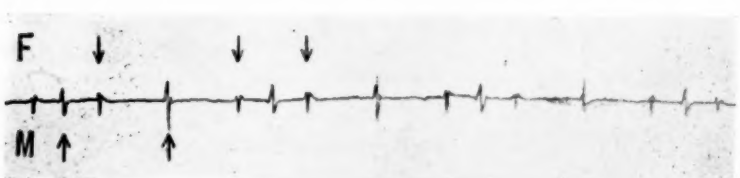

Fig. 4.—Twentieth week of pregnancy. Heart rates: fetal, 152; maternal, 103. Note relative large size of fetal complexes compared with maternal. In this portion of tracing every alternate maternal complex is almost synchronous with a fetal complex. An ordinary electrocardiograph using abdominal leads failed to record deflections of the fetal heart.

the seventeenth, eighteenth, twentieth, twenty-fifth, thirtieth, thirty-fourth, and thirty-eighth weeks of pregnancy, appear in Figs. 2-8.

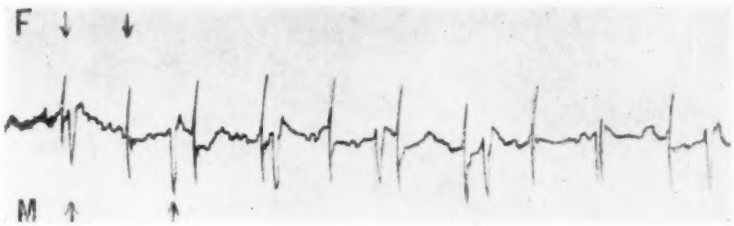

Fig. 5.—Twenty-fifth week of pregnancy. Heart rates: fetal, 158; maternal, 100. Note large fetal complexes.

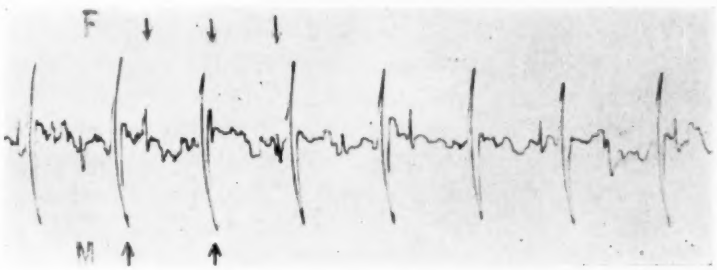

Fig. 6.—Thirtieth week of pregnancy. Heart rates: fetal, 162; maternal, 133.

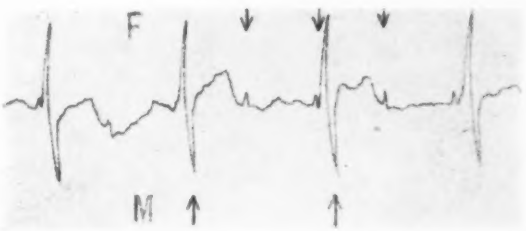

Fig. 7.—Thirty-fourth week of pregnancy. Heart rates: fetal, 155; maternal, 74.

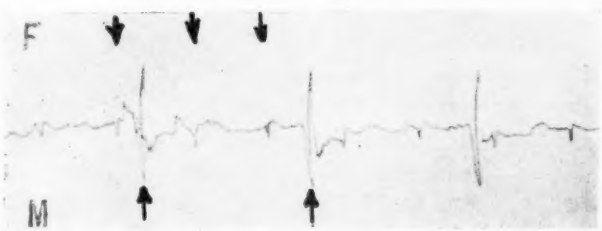

Fig. 8.—Thirty-eighth week of pregnancy. Heart rates: fetal, 148; maternal, 72.

For the purpose of comparison, records were obtained with the ordinary electrocardiographic apparatus and with Offner amplifier and crystograph from one patient, on the same day, using the same leads.

The former instrument, even with double standardization, failed to show any fetal waves; however, good fetal waves were obtained with the crystograph (Fig. 4).

DISCUSSION

Soon after the beginning of this study it became obvious that it was possible to record the fetal electrocardiogram earlier than the last two months of pregnancy, the earliest time recorded in the literature.[4] It then became of great interest to ascertain how early in fetal life it could be recorded. Although our earliest record was obtained in the sixteenth week, we suspect that positive records can be obtained earlier. The absolute minimum will be determined by the stage at which the fetal heart develops enough electromotive force to allow recording from leads on the maternal abdominal wall or in a body orifice. The embryology of the heart has some bearing on this aspect of the problem.

According to Arey,[6] the heart tubes fuse in the human embryo and the heart begins to beat at about 3.5 to four weeks. At this stage the embryo has sixteen to thirty-eight somites. In the rat, however, Goss[7] has observed that a small group of cells in the tubular anlage of the heart begins to contract at the three-somite stage. This is prior to the fusion of the tubes. Hoff, et al.,[1] found recognizable P-QRS-T waves at the twenty-somite stage (forty-two hours) in chickens. By the twenty-four-somite stage (forty-eight hours) the complexes were well developed, and in the 4-day-old embryo the electrocardiogram was very much like the adult chicken pattern.

It has been established by studies of human fetuses removed by operation that electrical impulses arising from the heart can be obtained with the electrocardiogram during the first four months of fetal life. Heard, Burkley, and Schaefer[8] studied eleven such fetuses. They recorded electrocardiograms, with chest leads, from fetuses of 9.5, 11.5, 12.5, 13, and 14 weeks of age. Marcel and Exchaquet[9] made a similar study of five cases. They were able to record waves similar to those of an adult at an early age. There is a discrepancy between the fetal ages and their sizes, in these five cases, and, according to accepted data of Arey,[6] they must have been somewhat older than the ages recorded. The earliest electrocardiogram with a pattern similar to that of the adult was obtained from a fetus which was probably about 6 to 7 weeks of age. Easby[10] recorded the electrocardiogram of another fetus which was 4.5 months old.

In the early stages of fetal life it is doubtful whether the electrical potentials of the fetal heart, as obtained with leads on the maternal abdominal wall, are great enough to be distinguished, because of the small irregular waves that are recorded from extraneous sources. That the potentials are present is indicated by the fact that they can be

recorded directly from the fetus itself. However, in view of the data in the preceding paragraph, it is theoretically possible to obtain fetal electrocardiograms with maternal abdominal leads after the fifth or sixth week of fetal life.

The problem of recording the fetal electrocardiogram earlier than the sixteenth week will probably resolve itself into one of technical improvement of the method. Since the beginning of the study our technique has undergone several improvements. At present our percentage of positive records during and after the seventeenth week of pregnancy is much higher than it was early in the study. It may be that with further improvement it will be even higher. However, the overall percentage of a method such as this is not important except as a general indicator of its usefulness. A positive record indicates that the intra-abdominal fetal heart is beating, and is of a great deal more importance than a negative record. As Bell[4] has said, "It can at least be said in its favour that, unlike many biological tests for pregnancy, it would not be expected to produce any false positives."

Abnormalities of the fetal heart rate have recently been emphasized as a good indicator of distress caused by anoxemia.[11] By means of this method, the fetal heart rate may readily be counted.

It seems to us that the present method has several advantages. After the initial expense of the instrument, an electrocardiogram can be taken at a very small cost. It is rapid, requiring only five to ten minutes. If the curve contains fetal waves, it proves that the fetal heart is beating. It is vastly superior to the ordinary electrocardiograph for recording fetal waves because of its greater sensitivity.

The method is useful clinically in the diagnosis of pregnancy, in ascertaining whether the fetus is living, in the diagnosis of multiple pregnancy (two or more sets of fetal waves), and, experimentally, as a tool for studying certain problems in fetal physiology.

The method has certain disadvantages. The machine is not commonly used at present except in research laboratories, although it may be no more difficult to operate than an ordinary electrocardiograph. The many small, irregular waves which appear on some tracings occasionally obscure the fetal waves. These can usually be eliminated by changing the time constants, thus bringing out the fetal waves and smoothing out the base line.

SUMMARY

An improved method for recording the fetal electrocardiogram is described; it uses the 3-channel electroencephalograph and crystograph ink writers.

Fetal waves were recorded successfully from the seventeenth week of pregnancy onward, and 82 per cent of the tracings taken during this period were positive.

Certain advantages and uses of the method are indicated.

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A STUDY OF SEVENTY RHEUMATIC FAMILIES

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RHEUMATIC fever today remains a major pediatric problem. The results of efforts to discover the etiological agent have been, for the most part, disappointing. The familial nature of rheumatism has long been recognized, and familial epidemiology offers an approach to the study of the disease.

Reports of the incidence of rheumatism in other members of families with rheumatic children have varied considerably, but all agree that there is an increased incidence of rheumatism in such families. What specific factor is responsible for the high familial incidence, however, is a controversial matter. Paul and Salinger[1] have noted that an epidemic of upper respiratory infection in families with a rheumatic member is often followed by the appearance of active rheumatism in several members of the family. They have noted also that such waves of rheumatism often occurred without any precipitating cause. Similar epidemics have been reported in schools, camps, hospital wards, and convalescent homes. Coburn[2] concluded that the "rheumatic state," as he called it, is a special type of response to chemical substances produced by infections of the upper respiratory tract. His observations pointed toward the hemolytic streptococcus as an etiological agent. The high family incidence is explained by this theory, with respect to both an hereditary predisposition and communicability. Numerous investigations have implicated other organisms as specific etiological agents. Recently, evidence that the cause is a filtrable virus has appeared in the literature.

Wilson,[3] in a recent study from New York, concluded that hereditary susceptibility underlies the familial incidence of the disease, although the possibility of other factors is conceded. She found no evidence of a contagious factor or any etiological relationship between respiratory infections and rheumatic fever. Read, Ciocco, and Taussig,[4] in a study from Baltimore, likewise concluded that heredity is the prime factor in the familial incidence. In addition, they had evidence which indicated that association with active rheumatism was also a factor.

A dietary deficiency as a possible factor underlying the high familial trend suggests itself. Rinehart, et al.,[5] have presented experimental and clinical evidence to indicate that vitamin C deficiency is an important factor. This work, however, has been challenged by Sendroy and

Inaugural thesis read before the Chicago Pediatric Society, Feb. 18, 1941.
Received for publication May 31, 1941.

Schultz.[6] A dietary study by Sadow, Hubbard, and Jones[7] did not show that diet was particularly related to rheumatic infection.

All who have studied the epidemiology of rheumatism agree that it is a disease of the lower economic classes. Findlay[8] found that not the very poor, but the between-class poor families, were those who suffered chiefly. The majority of the families in the group studied by Wilson[3] were those of the moderately well-to-do laboring class, with incomes of from $1,500 to $2,600 per year. Rheumatism is not rare, however, in the well-to-do classes. Findlay[8] reported fifteen well-to-do families which he had observed in fifteen years. Of these, 60 per cent had more than one rheumatic member. Coburn[2] studied a group of healthy student nurses at the Presbyterian Hospital in New York. They lived in excellent surroundings, without overcrowding, and had an adequate diet. In one year (1928) he found that 10 per cent of the group became ill with rheumatic disease. Upper respiratory infection was the only factor that could be associated with these cases.

The material for this study consists of seventy families, each of which has a rheumatic child attending the Christopher Public School. The family studies were begun in December, 1938, although many of the children were under observation in school for a longer time. We visited each home, and all available members of the family were examined, that is, the siblings, parents, grandparents, aunts, uncles, and cousins. Careful histories were taken of all members of the family, including those who were not available and those who had died. Whenever possible, the histories were checked with the clinic and hospital records. Social conditions were noted in relation to the rheumatic infection as they existed at the various periods. The diet habits were investigated, and food diaries were kept by each family. Follow-up visits were made when necessary. The dietary and social data were compiled and analyzed by one of us (R. L. R.), who is an experienced welfare nutritionist. Frequent follow-up visits were made by the school nurse, so that new developments were constantly recorded. It was felt that, by direct contact between us and the families in their homes, a more reliable survey could be made than if the data were obtained by other means which are frequently used.

The largest problem encountered in this study was the accurate diagnosis of rheumatism. It is very likely that the variations in the figures quoted on the incidence of rheumatism are partly due to different criteria for diagnosis. It is unfortunate that there is no specific test for rheumatism such as there is for tuberculosis. In this study, only those cases which were believed to be unquestionably rheumatic were included. The signs and symptoms considered to be diagnostic of rheumatism were (1) migratory polyarthritis, associated with other signs of general infection, and not caused by other specific disease, (2) chorea, (3) characteristic signs of rheumatic heart disease, (4) rheumatic nodules, and (5) rheumatic erythema.

It is important to differentiate the arthritis of rheumatic fever from other forms of arthritis, especially chronic infectious, or rheumatoid, arthritis. The latter usually causes deformities, but these are never found in rheumatic fever. Nodules are also sometimes seen in rheumatoid arthritis, and may be almost indistinguishable from true rheumatic nodules. However, the other manifestations will easily clarify the diagnosis. In this series, every patient with nodules also had definite rheumatic heart disease.

There are other signs and symptoms that are commonly found in rheumatic fever, but are not diagnostic of the disease. These are epistaxis, pallor, nervousness, loss of weight, abdominal pain, low-grade fever, anorexia, fatigue, anemia, and "growing pains." In the absence of more definite signs, however, none of these symptoms is diagnostic of rheumatic infection, and they are often encountered in other conditions. Children with these symptoms have sometimes been called prerheumatic subjects. However, whether there is a prerheumatic state is a much discussed subject. Findlay[8] found that in the great majority of his cases the onset was sudden and the symptoms clearly defined.

The significance of "growing pains" is debatable. Symptoms which are called "growing pains" frequently may be traced to a variety of causes, including foot strain, aching muscles, and epiphysitis. Many children have so-called "growing pains" with no demonstrable cause, and, on subsequent examination, do not generally show evidence of rheumatic heart disease. Although some "growing pains" are undoubtedly rheumatic, other manifestations must be present to confirm this diagnosis.

The interpretation of murmurs is another difficult problem. In the presence of the typical signs of mitral regurgitation or stenosis, there is little doubt of the rheumatic nature of the disease. However, systolic murmurs are often heard in normal children, and it is important not to confuse such harmless murmurs with those indicative of mitral disease. A soft systolic murmur which was maximum over the second left intercostal space was commonly encountered, but was not considered significant. A soft systolic murmur which was heard best over the lower part of the precordium, inside the apex, with slight transmission, was also considered functional unless it was accompanied by other signs of organic heart disease. Apical systolic murmurs are more significant. They are seen constantly in febrile conditions, and often in anemia, unassociated with rheumatism. However, a blowing systolic murmur which is maximum at the apex and is transmitted to the left, often replacing the first tone, is usually diagnostic of mitral insufficiency, especially if there is an accentuated pulmonic second sound. The other signs of rheumatic disease need not be discussed at this time. Most of our patients have been followed in clinics, and the diagnoses have been confirmed by roentgenograms and electrocardiograms. It is felt that by

TABLE I

	ROSENBLUM		WILSON		READ		FINDLAY		FAULKNER AND WHITE		IRVINE-JONES		STROUD		ST. LAWRENCE	
	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
A. Family Incidence—Parents and Siblings																
Total families	70		112		33		701		200		167 499		141		100	
Families with multiple rheumatic siblings	13	18.6				27.3	39	5.5								
Families with rheumatic parents	19	27.2	55	44.5		51.5	131	18.6								
Families with multiple rheumatic siblings and/or rheumatic parents	27	38.6			20	60.6			71	35.5	54 166	32 33		31	50	50
B. Parents and Siblings Listed as Individuals																
Siblings of index cases	322		387		110											
Rheumatic siblings of index cases	20	6.2	133	34.4	17	15.5										
Parents—rheumatic	20	14.3			20	30.8										
Total parents and siblings of index cases	462				175				1235						480	
Total rheumatic persons in above group	40	8.65				21.0				8.79					71	14.8
C. Other Family Members																
Total families	70				96		701									
Families with additional rheumatic members	35	50					243	34.7								
Families with rheumatic grandparents	4	6.5				57.0	32	4.5								
Families with rheumatic aunts, uncles, cousins	12	17.1					72	10.2								
No. of rheumatic grandparents	4	1.4														

Findlay, Glasgow, 1931.
Faulkner and White, Boston, 1934.
St. Lawrence, New York, 1922.
Stroud, Philadelphia, 1933.
Irvine-Jones, St. Louis, and Toronto, 1933 (two series).
Read, Baltimore, 1938-1939.
Wilson, New York, 1940.

using the above criteria there can be little doubt about the rheumatic nature of the cases so designated.

The family incidence of rheumatism, together with a comparison of studies in other localities, is shown in Table I. We found that approximately two-fifths of the families had at least one additional rheumatic member among parents or siblings, as did Faulkner and White,[9] of Boston. This makes an incidence of 9 per cent in terms of individuals. Fourteen per cent of the parents and 6 per cent of the siblings were involved. Stroud, et al.,[10] of Philadelphia, and Irvine-Jones,[11] with studies from St. Louis and Toronto, reported similar results. Coburn,[2] of New York, found about one-third of a group of 162 families involved. Although our figures are considerably higher than those of Findlay,[8] of Glasgow, they are much lower than those of Wilson,[3] of New York, and Read, et al.,[4] of Philadelphia. A large incidence was also found in relatives other than parents and siblings. At least one other member was found to be rheumatic in one-half of the seventy families studied.

TABLE II

FAMILY INCIDENCE AS INFLUENCED BY DIFFERENT CRITERIA FOR DIAGNOSIS

	DEFINITE RHEUMATIC CASES		INCLUDING QUESTIONABLE CASES	
	NO.	%	NO.	%
Families with other rheumatic members	35	50	45	64
Families with other rheumatic siblings	13	18.6	29	41.4
No. of other rheumatic siblings	20	6.2	51	15.9
Families with rheumatic parents	19	27.2	30	42.8
No. of rheumatic parents	20	14.3	33	23.6
Families with rheumatic grandparents	4	6.5	6	8.6
No. of rheumatic grandparents	4	1.4	6	2.25

The variations in the incidence may be attributed, to some extent, to geographic factors and to yearly variations in the occurrence of rheumatism. They may be due also to chance differences in the sampling. It has already been pointed out that differences in the criteria for diagnosis could be responsible for some discrepancies. The great extent to which this could influence the results is shown in Table II. We have included in the first group only those cases which we feel were unquestionably rheumatic. In the second group are included patients with symptoms and signs which could be mistaken for rheumatic heart disease or rheumatism. These include cases of chronic arthritis, traumatic arthritis, and functional and congenital murmurs. The unreliability of histories was brought out clearly. Children who were thought to have organic heart disease were frequently found to have functional murmurs, with no evidence of previous rheumatic attacks. On the other hand, many cases of unsuspected rheumatic heart disease were discovered in both parents and children.

The number of rheumatic siblings per family is shown in Table III; this varied from one to six, and in one family six of eight children had demonstrable rheumatic heart disease. This latter family also had a rheumatic mother. Table IV shows the total number of rheumatic persons per family, including the parents. This varied from one to seven.

TABLE III

NUMBER OF RHEUMATIC SIBLINGS PER FAMILY

No. of families	57	10	1	1	0	1
Total no. of siblings	293	74	8	9	0	8
No. of rheumatic siblings per family	1	2	3	4	5	6

TABLE IV

NUMBER OF RHEUMATIC PERSONS PER FAMILY (PARENTS AND SIBLINGS)

No. of families	43	20	4	2	0	0	1
No. of rheumatic persons per family	1	2	3	4	5	6	7

The relation of parental rheumatism to rheumatism in the children is indicated in Table V. In families in which one or both parents were rheumatic, there was a higher incidence of rheumatism in the children. This is reflected in the percentage of families and siblings involved. Index cases* were not included in this calculation.

TABLE V

INCIDENCE OF RHEUMATISM IN FAMILIES WITH RHEUMATIC AND NONRHEUMATIC PARENTS

A. CONSIDERING FAMILIES

PARENTAL GROUP	NO. OF FAMILIES	NO. OF FAMILIES WITH OTHER RHEUMATIC SIBLINGS	PER CENT
Both parents negative	51	8	15.7
One or both positive	19	5	25.6

B. CONSIDERING SIBLINGS

PARENTAL GROUP	TOTAL NO. OF SIBLINGS EXCEPT INDEX CASES	RHEUMATIC SIBLINGS	PER CENT
Both parents negative	250	10	4
One or both positive	72	10	13.9

A comparison of the incidence prior to and after association with patients in the active stage of the disease is demonstrated in Table VI. This is shown both for the group as a whole, and for families with positive and negative parental histories. The method used was the same as that employed by Read, Ciocco, and Taussig[4] in a similar study in

*By "index cases" we mean the seventy rheumatic children registered in the Christopher School.

Baltimore. The incidence of the disease, in terms of person years, was computed prior to and after association with a patient in the active stage of rheumatism. The first two years of life were not included because of the rare incidence of rheumatism at this age. Index cases were omitted in order not to bias the data. The results indicate that the incidence of rheumatism is about two and one-half times higher after, than prior to, association with a person who has the disease in an active stage. Again, it is evident that families with rheumatic parents show a higher incidence. These observations confirm the results of Read and her co-workers,[4] but our figures are generally lower. These data suggest that prolonged contact with a person who has active rheumatism predisposes to the development of new cases, thus implying a contagious factor. However, common environmental conditions may also be operative.

TABLE VI

INCIDENCE OF RHEUMATISM BEFORE AND AFTER ASSOCIATION WITH ACTIVE RHEUMATISM IN CASES PER 1,000 PERSON YEARS

	WHOLE GROUP	NONRHEUMATIC PARENTS 51 FAMILIES	RHEUMATIC PARENTS 19 FAMILIES
Before association	4.55	2.25	8.7
After association	10	6.6	20.4

Simultaneous attacks occurred in six of the thirteen families with multiple rheumatic siblings. In one family with four rheumatic siblings, three of them experienced attacks within one month. Attacks among parents and siblings occurred at the same time in four of the nineteen families with rheumatic parents. These simultaneous attacks did not have their onset on the same day, but were separated by several weeks or months. Unlike Paul and Salinger,[1] however, we did not find epidemics of respiratory infections preceding these attacks.

TABLE VII

PREDISPOSING FACTORS IN INDEX CASES

ASSOCIATED WITH RESPIRATORY INFECTIONS	NO.	%	NOT ASSOCIATED WITH RESPIRATORY INFECTIONS	NO.	%	
Upper respiratory infection or sore throat	15	21.4				
			Dampness	2	2.8	
Scarlet fever	7	10	Freezing	1	1.4	Chorea
Pneumonia	3	4.3	Psychic trauma	2	2.8	Chorea
Measles	3	4.3	Tonsillectomy and adenoidectomy	2	2.8	
Pertussis	1	1.4	Nothing	34	48.8	
Total	29	41.4	Total	41	58.6	

The predisposing factors in the seventy index cases are shown in Table VII. The association with respiratory infections is evident. It is

interesting to note that, in 10 per cent of the group, the onset of rheumatism occurred during convalescence from scarlet fever. In about one-half of the cases the first attacks of rheumatism were not preceded by respiratory infections. The reliability of the histories may again be questioned, because sore throats and other upper respiratory infections often go unnoticed in children.

TABLE VIII

RELATION OF TONSILLECTOMY AND ADENOIDECTOMY TO RHEUMATIC RECURRENCES*

AGE AT TIME OF OPERATION (YEARS)	TOTAL NO. OF PATIENTS	PATIENTS HAVING RECURRENCES	PER CENT
0-5	4	3	75
6-9	18	11	61
10 and over	12	5	41.6
Total	34	19	55.9

*Eleven of nineteen patients with recurrences had tonsillar stumps. Twelve patients had their first attack subsequent to operation, and four of these had tonsillar stumps.

The relation of tonsillectomy and adenoidectomy to the recurrence of rheumatism is shown in Table VIII. It appears that the age at the time of operation determines the number of recurrences; the older the child, the fewer the recurrences. Since this is the natural course of the disease, tonsillectomy and adenoidectomy do not seem to prevent recurrences. However, eleven of the nineteen patients with recurrences had tonsillar stumps, so that we are not justified in drawing conclusions from these figures. This is a possible source of error in any study dealing with the effect of tonsillectomy and adenoidectomy on rheumatism.

TABLE IX

RELATION OF TONSILLECTOMY AND ADENOIDECTOMY TO SEVERITY OF HEART DISEASE*

	GROUPS			
	I	II	III	IV
Tonsils out prior to first attack—clean	1	3	4	0
Tonsils out prior to first attack—stumps	1	2	1	0
Tonsils out after first attack—clean	3	10	5	4
Tonsils out after first attack—stumps	0	3	5	4
Tonsils in	2	6	9	7

*Heart condition is classified as I to IV, mild to severe. The figures indicate the number of cases in each group.

The relation of tonsillectomy to the severity of the heart damage is shown in Table IX. The degree of heart damage was classified as I to IV, varying from mild to severe. There were more cases of severe heart damage among the patients who had no tonsillectomy, or had tonsillectomy after the onset of the disease. These observations are similar to those of Kaiser,[12] who found that the mortality rate was much higher among the patients who either had no operation, or did not have it until after the first attack. He also found that tonsillectomy did not prevent recurrences.

The relation of family income to the incidence of rheumatism in other siblings is shown in Table X. The families were divided into two groups, namely, those receiving some form of relief and the self-supporting. There were thirty-three families in the self-supporting group, and their average yearly income was $1,460. The highest income of any single family was $1,800. The average income of the relief group could not be stated because of the varied ways in which the relief was administered. It is safe to assume that the relief group had a slightly lower average income than the private group. A study by the United States Department of Labor, in 1936, showed that one-half of the families in Chicago had incomes under $1,412, and that one-third of the families had incomes under $1,000. This included both private and relief families. Hence, although our series represents a low-income group, it is nevertheless representative of one-half of the families of Chicago. The self-supporting group fared worse in the incidence of rheumatism among the siblings. This may be due to a chance variation, but it agrees with the observations of others that rheumatism is not a disease of the extremely poor, but of the upper poor class. The income was also compared with the number and severity of attacks. The results do not permit definite conclusions, but the relief group seemed slightly favored.

TABLE X

RELATION OF INCOME TO INCIDENCE OF RHEUMATISM IN SIBLINGS

GROUPS	TOTAL FAMILIES	FAMILIES WITH OTHER RHEUMATIC SIBLINGS		TOTAL SIBLINGS	RHEUMATIC SIBLINGS	
		NO.	%		NO.	%
Relief	37	5	13.5	160	6	3.75
Self-supporting	33	8	24.2	162	14	8.64

A similar study was made of the possible effect of vermin on the incidence of the disease. The results showed no definite correlation.

In Table XI the condition of the homes, with respect to heat and dampness, is compared with the incidence of rheumatism in other siblings. Although one cannot draw conclusions from small groups such as these, it appears that a higher incidence of rheumatism in the sibling is associated with dampness. A comparison of heat and dampness with the number and severity of attacks was also made, but no correlations were noted.

Table XII shows the relation of diet to the incidence of rheumatism. Fifty of the seventy families kept a weekly dietary. This was analyzed from a qualitative standpoint only, for an accurate estimate of the amount of food consumed was not feasible. For this reason the caloric intake was not computed. It was interesting that the diets in general

TABLE XI

RELATION OF HEAT AND DAMPNESS IN HOME TO INCIDENCE OF RHEUMATISM IN SIBLINGS

	TOTAL FAMILIES	FAMILIES WITH OTHER RHEUMATIC SIBLINGS		TOTAL SIBLINGS	RHEUMATIC SIBLINGS	
		NO.	%		NO.	%
Insufficient heat and dampness	7	2	28.6	38	4	10.5
Sufficient heat—no dampness	41	8	19.5	191	13	6.8
Insufficient heat	19	2	10.6	82	4	4.9
Sufficient heat	51	11	21.6	240	16	6.6
Dampness	19	5	26.4	87	7	8.05
No dampness	51	8	15.7	235	13	5.53

TABLE XII

RELATION OF DIET TO INCIDENCE OF RHEUMATISM IN SIBLINGS

DIET GROUP*	NO. OF FAMILIES	FAMILIES WITH OTHER RHEUMATIC SIBLINGS		NO. OF SIBLINGS	RHEUMATIC SIBLINGS	
		NO.	%		NO.	%
I	10	2	20	43	6	14
II	15	2	13	64	2	3.1
III	15	2	13.3	84	2	2.4
IV	10	3	30	60	6	10

*Group I, Adequate. Group II, Deficient in vitamin C only. Group III, Inadequate. Group IV, Very poor.

were of the high-protein type. Since most protein foods are relatively expensive, they are usually purchased at the exclusion of other essential foods, especially fruits, vegetables, etc. The United States Government standards for a minimum adequate diet were used in classifying the diet groups. Four-fifths of the families used more than the minimum amount of milk. The diets varied mostly in the use of fresh fruits and vegetables. The families were divided into four groups, according to their food standards. Group I met all of the minimum requirements for an adequate diet. Group II was deficient in vitamin C, but met most of the other requirements. Group III was decidedly deficient in many essential elements. Group IV was the poorest of all.

According to this small series, there is no apparent correlation between diet and family incidence of rheumatism. In two of the families, one with four and the other with six rheumatic siblings, the diet of the former fell into Group IV, and the latter into Group I.

An analysis of the diets, as compared with the number and severity of rheumatic attacks, also failed to show any direct relationship. We must remember, however, that the diets met minimum, not optimum, standards. Only three of the family diets were on an optimum level. This reveals the need for a study of a similar group of families who have optimum diets.

SUMMARY

A group of seventy low-income families, each with a rheumatic child attending the Christopher Public School, was studied by us in their homes. The following observations were made:

1. There was a marked incidence of rheumatism in other family members.

2. The families with rheumatic parents had a higher incidence of the disease among the siblings than those with nonrheumatic parents.

3. The incidence was higher after association with a person who had active rheumatism. It was higher in families with rheumatic parents than in families with nonrheumatic parents.

4. Simultaneous attacks of rheumatism were frequently noted among siblings, and among parents and siblings. Waves of respiratory infections prior to those attacks were not noted.

5. Respiratory infections occurred preceding the onset of the first manifestations of rheumatism in slightly less than one-half of the cases. Scarlet fever preceded the onset in 10 per cent of the cases. In the cases which were not preceded by respiratory infections, a variety of factors were present, including exposure to dampness, chilling, tonsillectomy, and psychic trauma. There was no illness in a number of cases preceding the onset of the first rheumatic symptoms.

6. Tonsillectomy did not seem to influence rheumatic recurrences. The older the child at the time of tonsillectomy, the fewer the recurrences. Generally, however, the patients with severe heart damage were those who had not had a tonsillectomy, or had had it performed after the onset of the rheumatism.

7. An analysis of the incidence of rheumatism, as compared with the family income, showed a higher incidence in the self-supporting group than in the relief group. The self-supporting group was on a marginal income level, however. There appeared to be no correlation between the number and severity of attacks.

8. There was no correlation between the incidence of rheumatism and the presence of vermin.

9. In an analysis of home conditions, the only factor that could be correlated with an increased incidence of rheumatism was dampness. There was no correlation, however, between dampness and the number and severity of the attacks.

10. No relation between diet and the occurrence of rheumatism could be found. It must be emphasized that most of the families which were studied did not have an optimum diet.

CONCLUSIONS

1. Although there was some correlation between the incidence of rheumatism and dampness, there was no apparent relationship to other home conditions or to diet. It is to be emphasized, however, that all of the families were at the lower income level.

2. The outstanding observation was the marked familial trend in rheumatic fever, and the tendency toward simultaneous flare-ups in several members of the family.

3. If these results are correct, and studies in other localities bear this out, it would suggest that in dealing with this condition we should pay particular attention to infection in other members of the family. In this way it may be possible to prevent rheumatic infection in susceptible persons and to institute early treatment, once it has occurred.

We wish to express our appreciation to Dr. Philip Rosenblum for having suggested this investigation, and also to Dr. Louis Katz for his kind assistance.

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RESTING BLOOD FLOW AND PERIPHERAL VASCULAR RESPONSES IN HYPERTENSIVE SUBJECTS

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THE altered hemodynamics in the hypertensive state in man is still the subject of much speculation and controversy. Obviously, only four factors can be implicated in the production of the elevated blood pressure, namely, cardiac output, blood volume, blood viscosity, and peripheral resistance. There is general agreement that the cardiac output at rest is not increased in this condition,[1] although a number of reports[2] present conflicting and variable observations in this respect. The pertinent investigations on blood volume[3] and blood viscosity[4] likewise suggest that no significant differences exist between normal and hypertensive subjects, although here again there is some disagreement.[5] When it is assumed, however, that the above three factors are unaltered, or, at least, not affected to a degree sufficient to raise blood pressure significantly, the only remaining factor which could possibly account for the hypertensive state is an increase in peripheral resistance. This is the view of most workers in the field.

The question naturally arises as to whether or not this increased peripheral resistance is a generalized one. Since, according to Poiseuille's law, the pressure varies inversely as the fourth power of the radius of a vessel, it is evident that a slight increase in the tonus of the arterioles, even if limited to a single portion of the vascular bed, would be sufficient to cause a significant elevation in systemic blood pressure. Because of this theoretical possibility, together with evidence which, for the most part, is of an indirect nature, the concept that the vasoconstriction producing hypertension occurs chiefly, if not entirely, in the splanchnic area was advanced[6] and was universally accepted until recently.

Prinzmetal and Wilson,[7] using the venous occlusion plethysmographic method, studied thirty-two hypertensive and eighteen normal subjects and found that the average rate of resting blood flow in the forearm was the same in both groups. As a result of these observations, they concluded that the increased peripheral resistance is not limited to the splanchnic region, but exists in the extremities as well, i.e., that the hypertonus is generalized. Pickering[8] utilized the plethysmographic method for the forearm and Stewart's calorimeter for the reflexly vasodilated hand and arrived at a similar conclusion.

From the May Institute for Medical Research, The Jewish Hospital, Cincinnati.
Aided by the Samuel and Regina Kuhn Fund.
Presented before the American Heart Association, Cleveland, May, 1941.
Preliminary report in Proc. Soc. Exper. Biol. & Med. 45: 127, 1940.
Received for publication June 11, 1941.

The hand contains specialized blood vessels, the arteriovenous shunts, and blood flow through this vascular bed has been shown to be affected by a variety of vasoconstricting stimuli, even when the vessels are fully dilated.[9] Hence the objection can be raised on purely theoretical grounds that blood flow data obtained on the hand are not representative of peripheral blood flow generally. In the light of the recent work of Grant and Pearson,[10] the same criticism can be applied to a lesser degree to the above-mentioned results with the plethysmograph, for, although blood flow to the forearm was studied, no precautions were taken to prevent a variation in the quantity of venous return from the hand from influencing the determinations.

Stead and Kunkel[11] found that the peripheral vascular reactions of hypertensive patients to exercise and local heat were similar to those of normal subjects. Accepting the hypothesis proposed by Prinzmetal and Wilson, and by Pickering, they interpreted their observations to indicate that the increased peripheral resistance in the blood vessels of the extremities of hypertensive persons cannot be reduced to a normal level, even by powerful vasodilating agents.

In order to clarify some of these questions, we studied a relatively large number of normal and hypertensive subjects and submitted the data to statistical analysis. Resting blood flow readings were obtained on the forearm, leg, and hand by means of the venous occlusion plethysmographic method; special precautions were taken, in the case of the forearm and leg, to obstruct all venous return from the hand and foot. In addition, the peripheral vascular responses to local anoxemia and exercise were studied, as well as the state of the venous bed.

METHOD

The investigation included 160 subjects, of whom seventy were hypertensive and ninety were normal. In the hypertensive group the average systolic blood pressure was 195 mm. Hg; the highest was 255 mm., and the lowest, 150 mm. The average diastolic level was 112 mm.; the highest was 162 mm., and the lowest, 88 mm. In those instances in which the systolic pressure was below 160, or the diastolic below 95, one or the other was always sufficiently elevated to justify placing the subject in the hypertensive group. No attempt was made to classify the patients according to the generally accepted clinical categories, for a clear-cut differential diagnosis was often difficult or impossible to make. No subjects were used who showed any signs of cardiac failure, were suffering from auricular fibrillation associated with a pulse deficit, or manifested obvious arteriosclerotic changes in the lower extremities.

By means of the venous occlusion plethysmographic method, blood flow measurements, in cubic centimeters per minute per 100 c.c. of limb volume, were generally made upon two extremities simultaneously; the technique employed was identical in all respects with that previously reported.[12] The temperature of the water in the plethysmograph was kept at 32° C. During the measurement of blood flow in the forearm and leg, venous return from the hand and foot was prevented by maintaining a pressure which was much higher than the systolic level (350 mm. Hg, or above) at the wrist and ankle.

The routine of our experiments included a number of procedures. Generally, ten to fifteen control, resting, blood flow measurements were made at the beginning

and also at different times during the experiment, so that a satisfactory average might be secured. Then the effect of local anoxemia on peripheral blood flow was studied by applying an arterial occlusion pressure to the extremity, proximal to its insertion into the plethysmograph, for a period of five to ten minutes. Immediately after release of the pressure, blood flow was recorded every ten seconds for five to seven minutes. From these figures a graph was later constructed, and, by means of a planimeter, the number of cubic centimeters of excess blood flow, over and beyond the previously ascertained average resting level, was calculated.[13] The blood flow repayment was expressed as cubic centimeters of excess blood flow per 100 c.c. of limb volume per minute of arterial occlusion.

Next, the peripheral circulatory response to a standard amount of exercise was studied. This was accomplished by having the subject, with the forearm in a plethysmograph, squeeze an ordinary sphygmomanometer bulb in his hand fifty to sixty times in one minute, which was sufficient to raise the pressure in a 5-gallon bottle to 70 mm. Hg. The muscles utilized were, for the most part, limited to those in the forearm. This exercise could be accomplished without difficulty by all hypertensive patients whose general physical condition was good. An attempt was made to equalize the intangible factor of muscular efficiency by excluding any patients who were unable to perform this task, so that the reactions of the remaining hypertensive subjects could more justifiably be compared with those of the normal group.

Immediately after this exercise, blood flow records were obtained at ten-second intervals for four minutes, and thereafter at one-half minute intervals until the blood flow returned to the previous control level. As in the experiments on local anoxemia, in each instance a graph was constructed from the blood flow figures which were obtained, and, by means of a planimeter, the number of cubic centimeters of excess blood flow over and beyond the average control resting level was ascertained.

Finally, in order to obtain some information as to whether or not there is an increased tonus in the venous bed* in hypertension, the following procedure was carried out upon the forearm and leg. A base line was obtained by raising the recording pen attached to the Brodie's bellows to a mid-position and recording limb volume changes on a slowly moving drum. Since, as previously reported,[14] spontaneous volume changes are minimal in the forearm and leg, a constant base line was readily obtained. A pressure of 10 mm. Hg was then applied to the extremity proximal to its insertion in the plethysmograph, and the increase in the volume of the extremity was recorded on the drum, according to the technique described by Capps.[15] When the base line reached a plateau, the external pressure was again raised 10 mm. Hg. This procedure was continued in 10 mm. steps until a pressure of 70 mm. Hg was reached. The change of volume in the extremity, as recorded with each 10 mm. increment of pressure, was expressed as cubic centimeters of increase per 100 c.c. of limb volume.

In addition to the plethysmographic studies, blood pressure readings and pulse rates were taken at stated times during each experiment. In those instances in which there was some doubt about the presence or absence of congestive heart failure, circulation time measurements, using sodium dehydrocholate,† were also made.

RESULTS

Resting Blood Flow. Forearm.—In the hypertensive group, sixty-eight measurements were made upon thirty-seven subjects; the average

*Venous bed includes veins, venules, and capillaries, i.e., vessels which cannot constrict against an internal pressure of 70 to 80 mm. Hg and do not materially contribute to the peripheral resistance.

†We wish to express our thanks to Riedel-de Haen, Inc., who supplied this drug.

blood flow for the entire series was 2.86 c.c. per minute per 100 c.c. of limb volume, with a standard deviation of 1.2, and a standard error of the mean of 0.14 (Table I). In the normal group, 131 forearm measurements were made upon fifty-six subjects; the average for the entire group was 1.77 c.c. per minute per 100 c.c. of limb volume, with a standard deviation of 0.7 and a standard error of the mean of 0.06. The difference between the averages of these two groups is 1.09, and the standard error of this difference* is 0.15, giving it a reliability† of 7.1. The reliability of a difference must be at least as high as 3.0 to rule out the possibility that chance alone may have produced it. The difference between our means for normal and hypertensive patients has so high a reliability, however, that the likelihood of failing to find the same type of relationship on repetition of our experiments is less than one in a billion, statistically. It can therefore be stated definitely that the forearm mean blood flow of hypertensive patients is greater than that of normal persons.

TABLE I

RESTING BLOOD FLOW IN VARIOUS VASCULAR BEDS OF NORMAL AND HYPERTENSIVE SUBJECTS

	NO. OF SUBJECTS	NO. OF TRIALS	MEAN BLOOD FLOW	σ	σM	RELIABILITY OF DIFFERENCE OF MEANS
Forearm						
Normal	56	131	1.77	0.7	0.06	7.1
Hypertension	37	68	2.86	1.2	0.14	
Leg						
Normal	28	54	1.38	0.5	0.07	5.5
Hypertension	30	33	2.38	1.0	0.17	
Hand						
Normal	61	139	9.32	2.1	0.18	8.6
Hypertension	32	35	5.38	2.2	0.42	

All blood flow figures expressed in cubic centimeters per minute per 100 c.c. of limb volume.

σ, Standard deviation; σm, standard error of the mean.

The data for the forearm are graphically represented in Fig. 1, which shows the percentage of subjects who fell into each category of blood flow readings. Approximately 11 per cent of the normal subjects, but no hypertensive patients, fell into the lowest blood flow category of 0.5 to 1.0 c.c. The highest percentage of normal subjects (45 per cent) fell within the next group, but only 14 per cent of the hypertensive patients. In the 1.7 to 2.2 c.c. range, the percentage of cases was approximately the same in both groups, and, from this point on, the initial tendency was reversed, i.e., the hypertensive subjects predominated,

*Standard error of difference between means is derived from the formula: $\sigma m_1 - m_2 = \sqrt{(\sigma m_1)^2 + (\sigma m_2)^2}$.

†The reliability of the difference between two means is derived from the formula: Reliability of difference between means $= \frac{m_1 - m_2}{\sigma m_1 - m_2}$

with very few normal subjects in the higher categories. In other words, there was a significant shift among the hypertensive subjects toward the greater blood flow values, although the higher normal and lower hypertensive ranges did overlap.

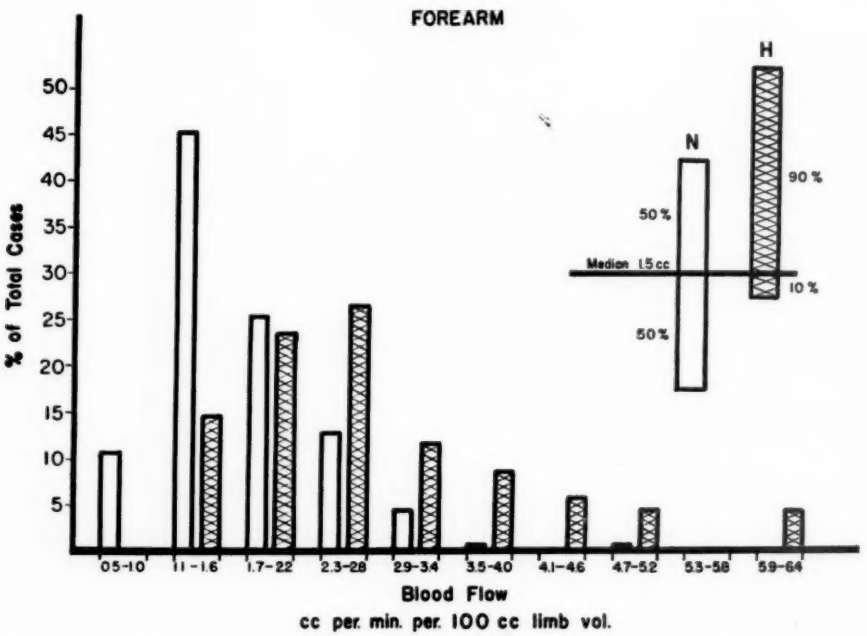

Fig. 1.—Distribution of blood flow readings in the forearms of normal (open column) and hypertensive (cross-hatched column) subjects.

These results are presented in a different fashion in Fig. 1 by relating them to the median* of the normal series. In the hypertensive group, 90 per cent of the forearm blood flow values were greater than, and only 10 per cent were less than, 1.5 c.c., which was the median of the normal series.

Leg.—Table I reveals that, as in the case of the forearm, the resting blood flow in the leg in the hypertensive group was significantly higher than that in the normal series; the reliability of the difference between the two means was 5.5. Graphically (Fig. 2), the distribution of the cases was found to be similar to that observed for the forearm (Fig. 1); an overlapping of higher normal and lower hypertensive ranges was also present.

Hand.—Because of the fact that marked vasomotor control is known to exist in the blood vessels in the hand, it was thought of interest to study the circulation in this site (Table I). Although only thirty-five measurements were made on hypertensive patients, as compared with

*By definition, a median is that figure which divides the cases so that exactly 50 per cent fall on either side of it.

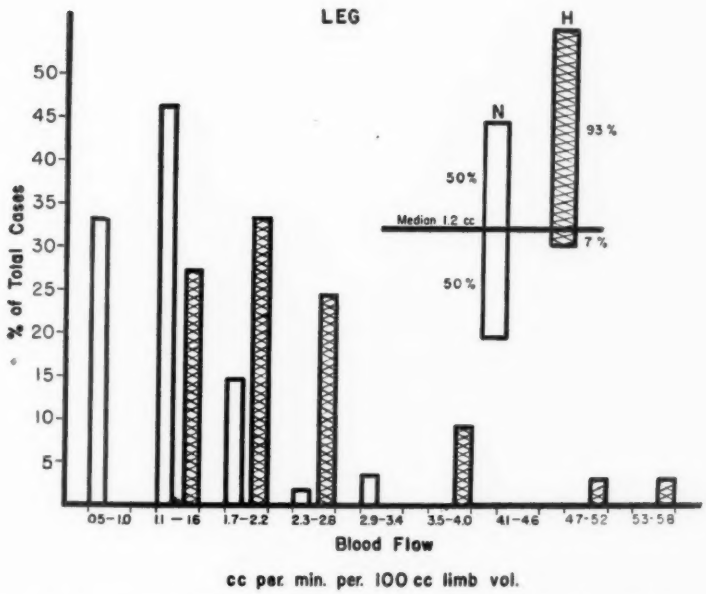

Fig. 2.—Distribution of blood flow readings in the legs of normal (open column) and hypertensive (cross-hatched column) subjects.

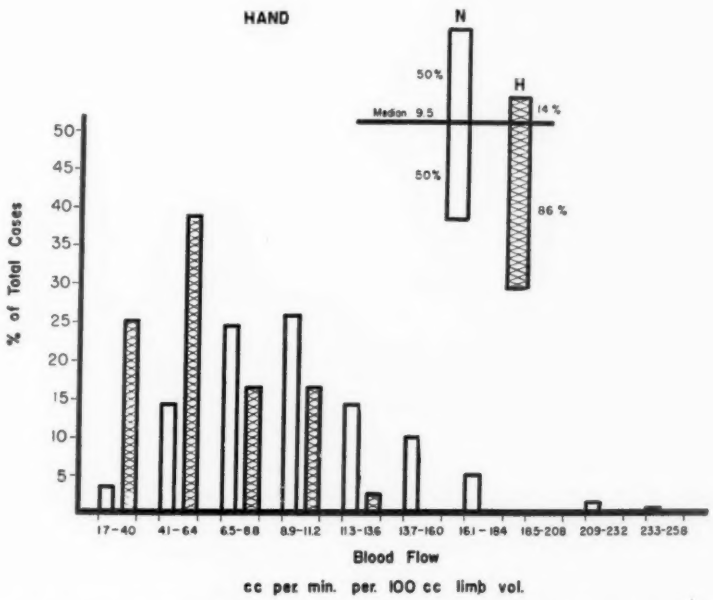

Fig. 3.—Distribution of blood flow readings in the hands of normal (open column) and hypertensive (cross-hatched column) subjects.

139 on normal subjects, the number was sufficient to indicate that the blood flow in the hand in the hypertensive group, in contrast with the forearm and leg, was significantly less than that in the normal group; the reliability of the difference between the two means was 8.6. These results are in accord with the calorimetric observations of Sheard and his associates.[16]

The results for the hand are graphically presented in Fig. 3. As is apparent, there is a definite tendency for the hypertensive series to shift toward the smaller blood flow ranges. The same type of relationship was evident when the data were related to the median of the control series (Fig. 3, right upper corner); 86 per cent of the hypertensive blood flows were less than, and only 14 per cent greater than, this value.

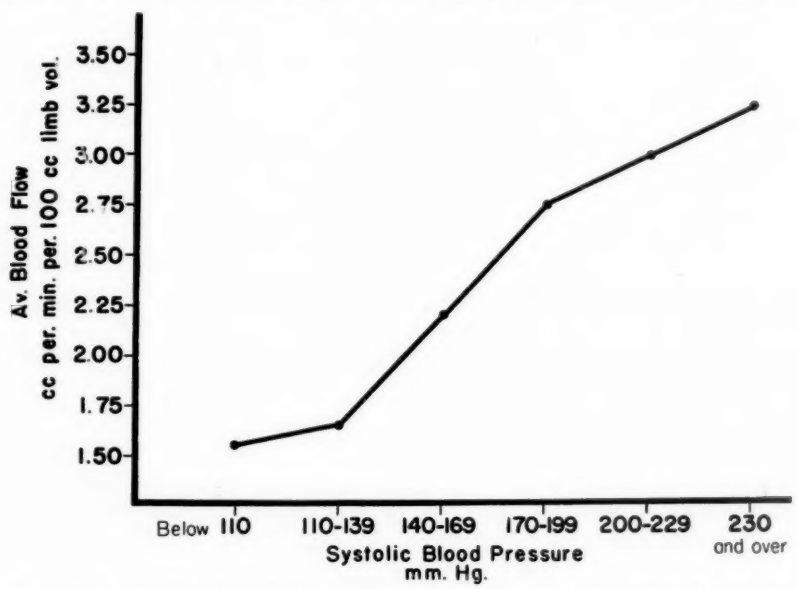

Fig. 4.—Illustrating the relationship between average forearm blood flow and systolic blood pressure for both normal and hypertensive subjects. Points represent average blood flow for each blood pressure range (coefficient of correlation = 0.65 ± 0.03).

Comparison of Rate of Resting Blood Flow and Height of Blood Pressure.—The question naturally arises as to whether there is any relationship between the rate of resting blood flow and the height of the blood pressure. In order to throw some light on this point, all forearm blood flow figures in both the normal and hypertensive groups were correlated with the blood pressure. The correlation coefficient between resting forearm blood flow and systolic blood pressure was 0.65 ± 0.03, indicating that there is a marked relationship between these two factors. Since diastolic pressure has great significance in its own right, blood flow was correlated with it as well; the resulting coefficient was 0.39 ± 0.05. This figure is lower than that for systolic pressure, indicating a less marked

relationship. The pulse pressure and blood flow were likewise correlated, and the coefficient was 0.64 ± 0.03, which is practically the same as that for systolic pressure.

Fig. 4 illustrates the significance of the coefficient of correlation. In it are plotted the average forearm blood flow figures of all subjects who fell within certain ranges of systolic blood pressure. It is apparent that the average forearm blood flow rises significantly with increases in blood pressure. The correlation coefficient of 0.65, as stated above, is a statistical measure of this trend.

Since age and hypertension are associated factors, the question of the extent to which age affects the relationship between blood flow and blood pressure becomes extremely important. In order to clarify this issue the technique of partial correlation was utilized. In effect, this procedure determined what the correlation would have been if all of the subjects had been of the same age. Applied to our data, the partial correlation between forearm blood flow and systolic blood pressure, with age held constant, was 0.57. Since the original correlation was 0.65, it can be seen that holding the age constant has altered the correlation very little. In other words, age, per se, is not a factor of any consequence in producing the relationship between blood flow and blood pressure.

Response to Local Anoxemia.—The effect of arterial occlusion was studied on twenty-two hypertensive patients; the data obtained in a previous investigation[13] were used as controls. In this latter study, which was performed on twenty-six normal subjects, it was found that the average blood flow repayment in the forearm was 1.48 c.c. per 100 c.c. of limb volume per minute of arterial occlusion, with a standard deviation of 0.3 and a standard error of the mean of 0.06. In the hypertensive subjects, who were tested under similar conditions, the average repayment in the forearm was 1.56 c.c. per 100 c.c. of limb volume per minute of arterial occlusion; the standard deviation was 0.7 and the standard error of the mean, 0.14. The reliability of the difference between the means of the hypertensive and normal groups was 0.5, indicating that there is no significant difference in response to local anoxemia between the two. Further, the magnitude of the maximal single blood flow reading during the period of reactive hyperemia was no greater for the hypertensive than for the normal subject.

Response to a Period of Exercise.—Tables II and III reveal that considerable individual variation in repayment to exercise was present in both hypertensive and normal groups. This can probably still be attributed to differences in general physical training, despite the fact that debilitated hypertensive patients had been eliminated from the series. The important fact brought out by the procedure, was, however, that, with one exception (S. E.),* the blood flow repayment consequent to

*A case of chronic nephritis; diagnosis subsequently was proved at necropsy.

exercise was of approximately the same magnitude in both types of subjects. Further, no apparent difference existed in the magnitude of the maximal single blood flow reading elicited by the exercise, or in the duration of the total period of blood flow repayment.

TABLE II

EFFECT OF EXERCISE ON BLOOD FLOW IN THE FOREARM OF NORMAL SUBJECTS

SUBJECT	REPAYMENT*	MAXIMUM RESPONSE†	TIME OF MAXIMUM RESPONSE (SEC.)	DURATION OF REPAYMENT (MIN.)
L. B.	38.3	9.1	15	13
A. F.	26.5	7.3	30	14
N. N.	19.5	8.0	30	7
R. H.	47.0	11.6	40	14
M. W.	19.9	8.4	15	15
A. S.	23.4	7.0	25	12.5
A. F.	28.5	7.9	10	15
B. W.	45.2	12.6	10	12

*Expressed in cubic centimeters per 100 c.c. of limb volume.
†Expressed in cubic centimeters per minute per 100 c.c. of limb volume.

TABLE III

EFFECT OF EXERCISE ON BLOOD FLOW IN THE FOREARM OF HYPERTENSIVE SUBJECTS

SUBJECT	REPAYMENT*	MAXIMUM RESPONSE†	TIME OF MAXIMUM RESPONSE (SEC.)	DURATION OF REPAYMENT (MIN.)
C. J.	20.6	7.9	30	17
M. G.	25.0	12.7	25	9
S. E.	116.1	18.9	30	23
A. M.	27.4	13.2	20	12
M. H.	20.4	8.2	10	9
M. B.	33.8	6.1	15	13
G. S.	34.6	10.1	20	12.5
L. A.	16.1	7.8	30	10.5
B. W.	40.8	9.6	35	17
B. B.	33.3	11.1	25	14.5
S. B.	35.3	11.2	25	12.5
A. P.	38.4	9.9	25	14
M. S.	46.2	15.4	20	11
L. B.	18.3	8.2	10	10
C. M.	47.8	18.0	10	12.5

*Expressed in cubic centimeters per 100 c.c. of limb volume.
†Expressed in cubic centimeters per minute per 100 c.c. of limb volume.

Venous Tonus.—The rationale for the procedure used in studying venous tonus in the extremities[15] in hypertension is as follows: On application to the limb of an external pressure which is greater than that already existing in the venous bed, there will be a passive distension of this portion of the vascular tree. This will continue until the internal pressure rises above that in the blood pressure cuff, at which point the blood will be leaving the extremity at the same rate as it enters. On application of a greater pressure, the venous bed will again be passively distended, and a further complement of blood will remain in the limb to swell its volume; this response continues with each rise in pressure until the venous bed is no longer capable of enlarging. If hypertonus existed

in this site, the application of the pressures should produce smaller increases in limb volume, since vessels with increased tone would tend to resist the passive stretching brought about by accumulation and stasis of blood. As a result, the internal pressure would mount rapidly to and beyond the level of the external pressure, so that a proportionately smaller amount of blood would be deposited in such a venous bed, as compared with one with normal tonus. Since the possibility exists that high internal pressures might be sufficient to overcome an existing venous hypertonus, only the data obtained with the lower pressures would be of value in this respect.

TABLE IV

VENOUS CAPACITY IN THE FOREARMS AND LEGS OF NORMAL AND HYPERTENSIVE SUBJECTS

	NO. OF SUBJECTS	CUFF PRESSURE (MM. HG)						
		10	20	30	40	50	60	70
Forearm								
Normal	14	0	0.10	0.35	0.50	0.42	0.47	0.45
Hypertension	21	0	0.16	0.45	0.46	0.44	0.45	0.52
Leg								
Normal	15	0.04	0.15	0.24	0.41	0.44	0.44	0.62
Hypertension	19	0.03	0.14	0.23	0.33	0.34	0.33	0.51

Figures represent the average increase in extremity volume, expressed in cubic centimeters per 100 c.c. limb volume, obtained with each successive application of 10 mm. Hg pressure, in the range from 0 to 70 mm. Hg.

Table IV reveals that there was no significant difference between the hypertensive and normal groups in the progressive volume changes elicited by the application of increasing external pressures to either the forearm or leg. These observations are compatible with the view that in hypertension the venous bed in the extremities is not in a state of increased tonus.

DISCUSSION

In the elucidation of the hemodynamics of hypertension, data based on the measurement of blood flow in the extremities quite properly play an important role. On the premise that the cardiac output is not increased in hypertension, and that the elevated blood pressure results from an exaggerated peripheral resistance, such studies can be of help in ascertaining the relative distribution of the hypertonus.

If a generalized and uniform vasoconstriction were present, the rate of blood flow throughout the body would be the same as that in normal subjects; the augmented pressure would be dissipated in overcoming the added resistance to the flow of blood through the arterioles. Conversely, if the hypertonus were localized (relatively or absolutely), the compensatory increase in the head of pressure, due to an augmented force of cardiac contraction, would produce a more rapid rate of blood flow through those remaining portions in which the caliber of the blood

vessels was normal. Furthermore, this increase in blood flow would vary directly with the increased height of pressure, in accordance with Poiseuille's law.

The observation in the present investigation that there is a significantly greater blood flow through the forearms and legs of hypertensive patients than in those of normal subjects would therefore be opposed to the prevailing view that the vasoconstriction which produces hypertension is evenly distributed throughout the splanchnic region and the extremities.[11, 17] In fact, the data lend definite support to the alternate hypothesis that the hypertonus is not uniform, for they indicate that the blood vessels of the forearm and leg share little, if at all, in the increased peripheral resistance. The observation that a high correlation exists between the magnitude of forearm blood flow and such factors as the height of systolic blood pressure, the height of diastolic blood pressure, and the magnitude of the pulse pressure would be in accord with this view. Finally, the fact that such vasodilating agents as local anoxemia and exercise elicited the same type of response in both hypertensive and normal subjects would indicate that the tonus of the vessels of the forearm in the two groups was alike. The identical results of other investigators,[7, 8, 11] who favor the opposite concept, can be reinterpreted in a similar manner.

However, since it cannot be stated with absolute certainty that the augmented blood flow through the forearm and leg in hypertension is the resultant solely of an increase in tonus elsewhere in the vascular bed, it may be that other methods will have to be utilized before conclusions of a final nature can be made on this subject.

It is of interest to speculate as to why the average resting blood flow in the hands of hypertensive patients was significantly less than that in the control series, whereas the reverse was true for the forearm and leg. The fact that the hand is composed principally of skin, with its numerous arteriovenous shunts, whereas, in the forearm and leg, muscle tissue predominates, may in some way explain the different responses of the two types of vascular beds. As already stated, the blood vessels of the hand are under the control of the vasomotor center, but those in the forearm and probably the leg are little, if at all, affected by vasoconstrictor impulses.[9] Hence, the various psychic stimuli attendant upon the introduction of a lay subject into the environment of a laboratory would tend to decrease blood flow through the hand. In view of the generally accepted fact that the blood pressure rise consequent to the application of noxious agents is much greater in the hypertensive than in the control subject, the possibility suggests itself that the low hand flow observed in the hypertensive patients was the result of an exaggerated response to the psychic stimuli associated with the procedure. Nevertheless, the other possibility, that in hypertension the nervous vasoconstrictor tonus in the blood vessels of the hand is increased, can by no means be ignored.

SUMMARY

1. The rate of resting blood flow was studied in a series of seventy hypertensive and ninety normal subjects by means of the venous occlusion plethysmographic method.

2. It was found that in the hypertensive patients the resting blood flow in the forearm and leg was significantly greater than that in the normal group.

3. In the hand, however, the average blood flow was much less in the hypertensive than in the control subjects.

4. The fact that the blood vessels in the hand are under the control of the vasomotor center, whereas those in the forearm and leg are little, if at all, affected by vasoconstrictor impulses, was considered significant in this respect.

5. A period of local anoxemia was found to elicit a response of equal magnitude in both the hypertensive and the normal subject.

6. Similarly, the blood flow repayment after a specified amount of work was the same in the two groups.

7. Evidence was obtained which suggested that the venous bed in the extremities in hypertension is in a state of normal tonus.

CONCLUSIONS

These observations are in direct contradiction to the prevailing theory that there is a generalized and uniformly increased peripheral resistance in hypertension. On the premise that cardiac output is not increased, most of the available data would be compatible with the view that the tonus of the blood vessels of the forearm and leg is either normal or only slightly altered.

The authors wish to acknowledge the generous cooperation of Dr. A. N. Franzblau.

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DISCUSSION

Dr. J. Murray Steele, New York, N. Y.—There is a question whether or not loss of heat to the surrounding medium does not have a good deal more to do with flow through the superficial vessels of the skin than it does with that of the muscles and the deeper vessels of the forearm.

Dr. Louis Katz, Chicago.—Dr. Landowne, in my department, has been studying peripheral blood flow with the leg-foot plethysmograph of Abramson and has analyzed, among other things, the flow in a number of hypertensive patients. We found that the maximal flow after reactive hyperemia is usually normal; only on a few occasions did we find a maximal flow that was greater than normal. I should like to ask Dr. Abramson if he found that the maximal flows in reactive hyperemia in the forearm or leg, exclusive of the hand or foot, were greater than, the same as, or less than, the normal maximal flow. I believe that the use of such maximal flows would be a better indicator than resting flows of the presence of permanent irreversible changes in the state of those vessels, for resting flows depend upon a variety of other influences.

Further, I should like to ask him whether he has any information to help ascertain whether the differences in resting flow which he observed in different patients depended upon the duration of the hypertension or its etiological background.

DR. IRVINE PAGE, Indianapolis, Ind.—I believe there is a moral to be drawn from this discussion, and that is that people who are working with hypertension tend toward extremes, as you doubtless all recognize.

Four or five years ago, with the announcement of Prinzmetal and Pickering's work, there was a violent reaction against the nervous system, and the splanchnic area, especially, lost caste at a most alarming rate. On second thought, it did look as though the splanchnic area was an important vascular area, and that we had gone too far in minimizing its importance. The splanchnic area is now coming back into its old place again.

DR. WILLIAM S. COLLENS, Brooklyn, N. Y.—Regarding the plethysmograph, one must immediately question the reliability of this indirect method for the measurement of blood flow through a limb. Those of you who have had experience with the plethysmograph will agree with me that certain artifacts will frequently appear which may greatly mislead the observer. Dr. Abramson himself recently published a series of artifacts in plethysmographic determinations which, if used for physiologic interpretation, would lead to erroneous conclusions. I have been impressed and annoyed with this troublesome problem in my own plethysmographic studies. The slightest deviation in any of the numerous steps in the technique easily results in curves of most bizarre variations. A method so easily influenced cannot be regarded as a reliable method for indirectly interpreting blood flow.

I believe it is very important for us to wait for the final conclusion regarding the rate of flow through the limbs until a more reliable method is found.

DR. CHARLES NEUMANN, New York, N. Y.—I did not understand clearly what precautions Dr. Abramson took to make sure that the patients he was studying were willing to take part in the experimental work.

I say that because in one series of hypertensive subjects in which we tried to find the time of reaction of constriction of the blood vessels after a stimulus we were able to demonstrate a marked difference from the normal. The blood vessels of hypertensive subjects reacted with constriction in only 40 per cent of the number of stimuli applied, whereas the percentage was 70 for the normal subjects. This was true for practically every one of the hypertensive subjects and every one of the normal subjects. It was not simply a question of averages.

Then we changed the entire laboratory, making it more like a bedroom, and immediately the per cent of reaction for the hypertensive group jumped from 40 to close to 70. The patients said they felt more relaxed, and apparently they did not offer as much mental or psychic resistance to the work that was being done.

Now it is a question, of course, whether the hypertensive patient is more commonly in a situation that is pleasing to him or not, but I believe that it is important to evaluate very closely the environmental conditions of any investigation upon the conscious human subject in order to know now how normal or abnormal the situation presented to the patient may be.

DR. HENRY A. SCHROEDER, New York, N. Y.—The paper we have just heard should be very interesting to those who are investigating the nature of the increased peripheral resistance in arterial hypertension. For several years it has been believed that this resistance was generalized; that all arterioles throughout the body, with the exception perhaps of those in the kidney, were constricted equally. The evidence at present suggests that in many cases a humoral mechanism is involved. Attempts have been made to discover some substance which would reproduce these effects. There are several naturally occurring substances which constrict blood vessels of certain areas preferentially. If, as these papers suggest, the vascular constriction in hypertension is generalized but not equal, perhaps we should alter somewhat our point of view in a search for a pressor substance of which these effects may be the result.

DR. DAVID I. ABRAMSON, Cincinnati, Ohio.—I heartily agree with Dr. Steele's statement, and I am sure that Dr. Sheard does, too. As previously mentioned, we found that, when we studied the hand alone, we obtained a decrease in flow; Dr. Sheard found that he could draw the same conclusion in reference to his own data. Therefore, contrary to what Dr. Collens states, the results of the two investigations, using different methods, are not opposed to each other, but, in fact, each set of data supports the other, as far as the hand is concerned.

In reference to plotting diastolic blood pressure against blood flow, we have done this and find that there is a correlation between the two, although it is not so striking as in the case of systolic pressure and blood flow.

In reference to Dr. Katz' question, we did some work on the foot alone and also found that the blood flow in this region was normal or even somewhat diminished in hypertensive subjects. It might be expected that the foot would respond qualitatively like the hand, since both sites contain specialized blood vessels, the arteriovenous shunts. Therefore, the finding of a normal or low blood flow in these regions does not in any way vitiate the results that we obtained when we studied the forearm alone or the leg alone, in both of which arteriovenous shunts are absent.

As far as maximal response to reactive hyperemia is concerned, we feel that making one reading at a certain time after the release of the arterial occlusion pressure is not as reliable as obtaining the complete repayment by the construction of a graph from readings obtained every ten seconds until the blood flow returns to the normal level. However, in our procedure we also ascertained the maximal single response incidentally, and we found that it was no greater in hypertensive patients than in normal subjects. In other words, the degree of vasodilatation elicited by local anoxia was approximately the same in both.

We did not attempt to ascertain whether there was any relationship between height of blood flow and the type and duration of the hypertension, for we found that it was rather difficult at times to make clear-cut clinical diagnoses and to be sure in which of the generally accepted clinical categories a case fell.

In reference to Dr. Collens' objections (which, incidentally, seem to be perennial), obviously, one's results are significant only if the method is reliable and the data reproducible. We are quite well aware and have always been critical of any type of artifacts, and have, of course, discarded any records in which they were present. If the extremity is pushed into the machine, as mentioned by Dr. Collens, this is very readily apparent, and also when it is pulled out. As previously pointed out, Dr. Collens' other remark on the supposed difference between Dr. Sheard's and our results has no basis, for actually both sets of data lead to the same conclusions.

As far as environmental conditions are concerned, in reference to Dr. Neumann's question, we also tried to make our laboratory look as much like a bedroom as was possible under the circumstances. Further, no one was allowed to come into the room while the procedure was being carried out, and no loud conversation or noise of any sort was allowed because of the fact that the hand particularly, as well as the foot, responds markedly to all noxious stimuli by constricting. This would not apply to the forearm and leg, for the blood vessels in these sites are not under the control of the vasomotor system.

COARCTATION OF THE AORTA IN CHILDREN

The Syndrome of Constriction of the Isthmus of the Aorta, With Involvement of the Origin of the Left Subclavian Artery

Sidney P. Schwartz, M.D., and David Greene, M.D.
New York, N. Y.

IT HAS been pointed out by the anatomic studies of Theremin,[1] Vierordt,[2] Bonnet,[3] and Evans[4] that the most common type of constriction of the arch of the aorta which is encountered in those who survive infancy with this lesion is an abrupt narrowing of the isthmus in the region of the aortic termination of the ductus arteriosus, or adjacent to it. The arterial trunks arising from the aorta proximal to this narrowed portion of the arch are usually dilated and widely patent. This accounts for the well-known clinical manifestation of a marked disparity between the force and strength of pulsation, with elevation of arterial pressure, in the vessels of the upper extremities as compared with the abdominal aorta and its peripheral branches.

A more uncommon and atypical form of congenital abnormality of the aortic arch consists in a narrowing of that vessel between the origins of the left carotid and the subclavian arteries; the orifices of these arterial trunks may be compromised, or the vessels themselves may be congenitally narrowed. The clinical manifestations associated with such anatomic changes are so unique that coarctation of the isthmus of the aorta, with involvement of the left subclavian artery, should be suspected as readily as the more common form.

REPORT OF CASES

Case 1.—A. P., a girl, aged 8 years, was admitted to the Children's Cardiac Clinic of the hospital Dec. 19, 1933, and died at home Dec. 12, 1939. She was the seventh of eight children born in the United States of Italian parentage.

Her birth was normal, but she did not begin to walk until she was 4 years of age. The development of her teeth and nails was delayed, and it was noted that she was mentally retarded. Her progress in school was always very slow, so that at the age of 14 she was only in the fourth grade of elementary school.

She had measles and mumps at the age of 5 years. At 8 years she could climb five flights of stairs without any complaints. In this year a school physician recognized the presence of a heart lesion.

Physical examination on her first admission to the clinic revealed that she weighed 43 pounds and was 41 inches tall. Six years later, at the age of 14, she

From the Medical Division of the Montefiore Hospital for Chronic Diseases.
Received for publication May 28, 1941.

weighed 74 pounds and was 53 inches tall. That is, in a period of six years she had gained only 31 pounds in weight and 11 inches in height.

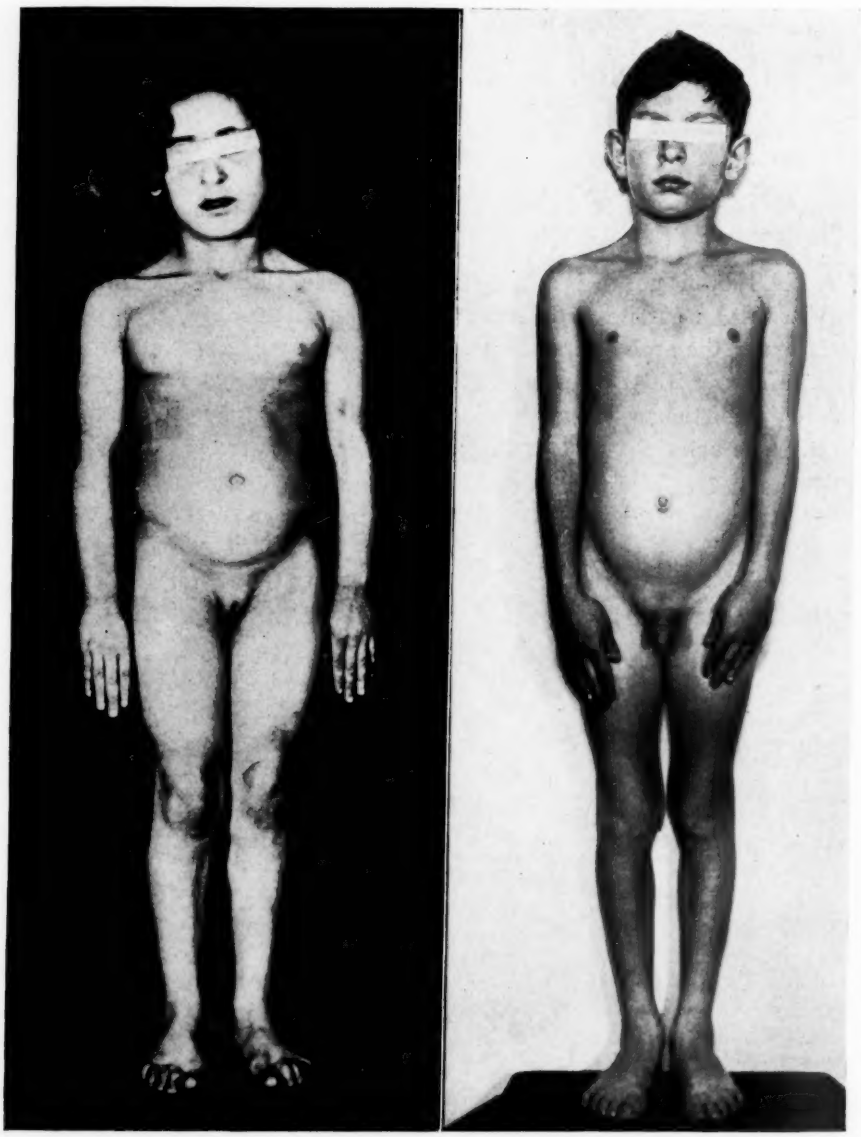
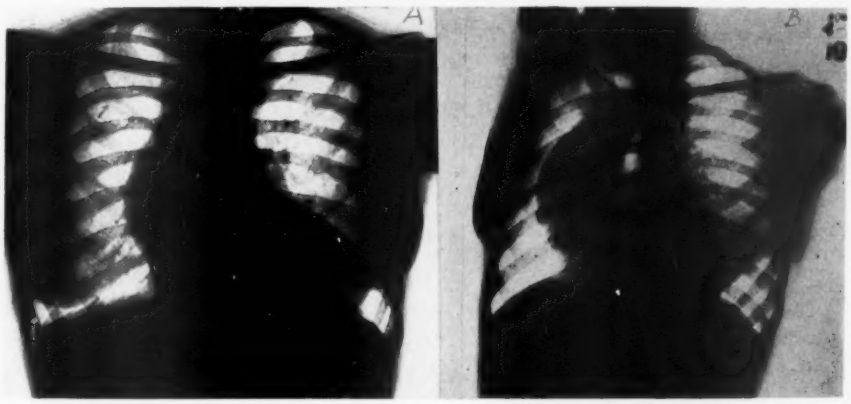


Fig. 1.—Photographs of both patients, showing overdevelopment of the right upper extremity as compared with the left upper extremity. Note that the right arm in both children is longer than the left arm. The circumferences of the right arms are likewise larger (for comparative measurements see the text).

She was a dark-complexioned girl with a head that appeared too large for her body. The right side of her face appeared fuller than the left. The right half of the chest was larger and more muscular than the left, and the right arm was 3 cm. larger in circumference than the left (Fig. 1). No pulse was palpable in the left radial, axillary, or subclavian arteries, and no pulsations were obtainable in the

abdominal or femoral vessels. There was a forceful pulsation of the arteries in the suprasternal notch, and the subclavian underneath and below the right clavicle pulsated forcibly. No blood pressure readings could be obtained in the legs.

The apical impulse of the heart was palpable in the fifth intercostal space 6 cm. to the left of the midclavicular line. A loud, blowing, systolic murmur was audible over this region, and the aortic second sound was louder than the pulmonic second sound. The lungs were free from moisture. The liver and spleen were not palpable. There was no edema of the lower extremities.



A. *B.*

Fig. 2.—*A*, Roentgenogram of the heart in Case 1, in the anteroposterior view, showing marked enlargement of the left ventricle, absence of the aortic knob, aneurysmal dilatation of the supraventricular portion of the aorta, and erosion of the ribs on the right side only. *B*, Roentgenogram of the heart in Case 1, in the left oblique position, showing enormous aneurysmal dilatation of the supraventricular portion of the aorta and narrowing of the arch in proximity to the spinal column. Note the enlargement of the aorta immediately below the constriction.

Fluoroscopic examination of the chest revealed that the lung fields were clear. The heart showed marked enlargement of the left ventricle; the rounding occupied the lower two-thirds of the heart, and extended below the diaphragm. In the anteroposterior view the aortic knob could not be visualized. The ascending portion of the aorta was markedly dilated, and this could be best seen with the child in the left oblique position. A loss of continuity of the aortic arch could be visualized in proximity to the site of coarctation. There was slight dilatation of the aorta distal to this region.

Roentgenograms of the chest confirmed these observations, and also revealed erosion of the caudad portions of several of the ribs on the right side only (Fig. 2).

The electrocardiogram showed left axis deviation, with a negative T wave in Lead III. Complete studies of the osseous system did not reveal any significant changes. The blood Wassermann reaction was negative.

Course and Progress.—On Oct. 22, 1935, a diastolic murmur was audible for the first time in the region of the second intercostal space to the right of the sternum. This was transmitted to the right shoulder and was also heard well in the back, between the shoulder blades. At this time a shock could be felt over the second intercostal space to the right of the sternum; it was synchronous with the closure of the aortic valves. The blood pressure was now 140/80 mm. Hg in the right arm, but no pulse or blood pressure reading was obtainable on the left arm, abdomen, or legs.

With the progressive development of the aortic insufficiency the blood pressure in the right arm increased gradually so that, on May 31, 1938, it was 170/68 mm.

Hg. The pulse in the right arm was now collapsing in type, and the pulsations of the subclavian artery and carotid on this side were much more forceful; both of these pulsations were almost wholly absent on the left side. Her basal metabolic rate was plus 33 per cent. In the summer of this year she began to experience occasional fever, unaccompanied by joint pains. Some of these febrile periods lasted over a week, and, in the course of a few weeks, the temperature remained persistently elevated, so that she had to go to bed. She now complained of severe headache, dizziness, profuse sweating, and shortness of breath even at rest. Her mental reactions became slower and inadequate. She could not remember her birthday and failed to answer simple questions.

On Sept. 9, 1939, her spleen was palpable 3 cm. below the costal margin, and, because of the increasing malaise and fatigue, she was admitted to the wards of the hospital.

Examination on this day revealed that she was very pale. She showed a typical "café au lait" color. Her temperature was 101.2° F., her pulse rate, 128 per minute, and her respiratory rate, 28. The blood pressure in the right arm was now only 116/86 mm. Hg. The trachea was pulled slightly to the left side. The right carotid vessels pulsated forcibly, and a systolic thrill was palpable over them. On the left side the pulsations were barely visible in the carotid sheath.

Measurements of the chest showed that the distance from the spine to midsternum on the right side was 38 cm., and 36 cm. on the left side. The left breast was slightly higher than the right. The muscles on the right half of the back were much better developed and more voluminous than those of the left side. The right arm was 1.5 cm. longer than the left, and the circumference of the middle of the right arm was 2.75 cm. larger than that of the left. The right wrist measured 13 cm. in circumference, and the left, only 12.75 cm. The circumference and length of both legs were equal, except for the right ankle, which was 0.5 cm. larger than the left.

TABLE I

CASE 1. OSCILLOMETRIC READINGS FROM ALL FOUR EXTREMITIES

RIGHT					MM.	LEFT				
A	B	C	D	E	Hg	A	B	C	D	E
½	m*	m	m	1	140	⅛	⅛	0	0	0
½	m	m	3	3	120	⅛	⅛	0	0	0
½	½	m	3½	3½	100	⅛	⅛	m	½	¼
¾	½	¼	3½	3½	80	½	¼	m	¾	¼
¼	¼	m	1	1	60	¼	¼	m	¼	¼

A, mid-thigh, normal oscillation from 6 divisions up.
B, mid-calf, normal oscillation from 4 to 6 divisions.
C, ankle, normal oscillation from 2 to 4 divisions.
D, upper arm, normal oscillation from 6 divisions up.
E, forearm, normal oscillation from 3 divisions up.
*Barely perceptible oscillation.

The oscillometric readings showed a marked diminution in the left arm (Table I), and a marked reduction in the oscillations in both lower extremities. Repeated blood cultures revealed the *Streptococcus viridans*. The heart now beat forcibly. A systolic thrill was palpable at the aortic area. There was a loud systolic murmur which was heard best at the apical region of the heart, and a loud to-and-fro murmur at the second intercostal space to the left of the sternum which was transmitted to the apical region of the heart.

No collateral pulsations were noted on the chest wall, and again there was no palpable pulsation in the left radial artery, the abdominal aorta, or the vessels of the lower extremities.

Comment.—A diagnosis of coarctation of the aorta, with involvement of the left subclavian artery, was made on a girl who showed asymmetrical development of the upper half of her body. No pulses were palpable in the left subclavian, axillary, or radial arteries, and no blood pressure readings could be obtained in the left arm or the lower extremities. She developed subacute bacterial endocarditis, with aortic insufficiency, and died as a result of this complication.

CASE 2.—R. H., a boy, aged 9 years, was brought to the clinic for advice on the possibility of ligating a patent ductus arteriosus which had been recognized at the age of 3 years.

He was a premature baby, but nothing unusual was noted at birth except a murmur which was heard all over the precordium. During his first years of life, his chest was noted to bulge anteriorly on the left side. He had had the usual diseases of childhood, but had never been ill enough to warrant a long period of rest in bed.

Physical examination on Oct. 30, 1940, revealed a malnourished boy who weighed 55 pounds and was 50 inches tall. He was slightly cyanotic and showed a pasty, circumoral pallor. His face was slightly asymmetrical. The right arm measured 52 cm., and the left, 47.5 cm., from the acromioclavicular joint to the middle of the third finger. The circumference of both upper arms was 18 cm. The circumference of the right fist was 20 cm., and that of the left was 19 cm. (Fig. 1).

The right carotid, axillary, and radial arteries were definitely palpable. The left carotid artery was barely palpable, but the left axillary, brachial, and radial arteries were not palpable at all. No pulsations were felt over the abdominal aorta, and the pulsations over both femorals were markedly diminished.

He had a marked deformity of the chest in the region of the left half of the sternum and the second, third, fourth, and fifth costosternal junctions, with no abnormal curvature of the spine. The superficial veins of the chest were dilated on both sides anteriorly. There was a heaving impulse, systolic in time, extending from the second to the fourth left intercostal spaces in the midclavicular line. Closure of the pulmonic valves was palpable within the nipple line. Over that region, a very loud "machinery" murmur was heard best at the second intercostal space to the left of the sternum. The pulmonic second sound was markedly accentuated. The diastolic element of the murmur was transmitted to the level of the third intercostal space, and the systolic element, to the left of the sternum as far up as the left clavicle. No murmurs were audible posteriorly.

The blood pressure in the right arm was extremely variable. One time it was 84/56, and at another time it was 90/68. Blood pressure readings could not be obtained from the left arm or either of the lower extremities.

The lungs were free from moisture. The liver and spleen were not palpable. There was no edema of the lower extremities.

Fluoroscopic examination of the chest revealed that the left ventricle was definitely enlarged. This enlargement was best seen with the patient in the left oblique position. In the anteroposterior view there was tremendous dilatation of the pulmonic artery, and its secondary branches pulsated so forcibly that there was a very definite "hilar fling." The supraventricular portion of the aorta could be visualized, but the tremendous dilatation of the pulmonic artery made it impossible to see the descending portion. A roentgenogram of the chest confirmed these observations (Fig. 3).

Contrast visualization of the heart and great vessels showed an indentation on the left side of the superior vena cava, with slight compression, presumably by

the pulmonic artery.* The right auricle and right ventricle were of normal size. The intraventricular septum was convex to the right when the right ventricle was filled. The pulmonic artery showed marked dilatation from its origin to its bifurcation. The left pulmonic artery was visualized, and was perhaps slightly dilated, but not in proportion to the dilatation of the main artery. There was no evidence of a communication between the right and left ventricles. The left ventricle was normal in size. The aorta was slightly dilated at its base. It was visualized indistinctly as far as the level of the left pulmonic artery. When the aorta was visualized faintly, there was still a slight residual opacification of the pulmonic artery. A reflux into the inferior vena cava was noted during the early phase of injection.

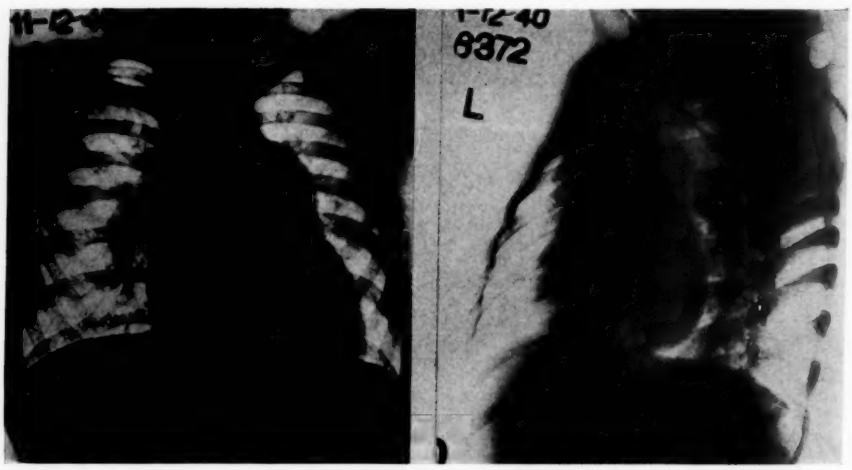


Fig. 3.—Roentgenograms in Case 2, revealing unusual dilatation of the pulmonic artery in the anteroposterior view. Note the absence of any erosion of the ribs.

TABLE II

CASE 2. OSCILLOMETRIC READINGS FROM ALL FOUR EXTREMITIES

RIGHT					MM.	LEFT				
A	B	C	D	E	Hg	A	B	C	D	E
m*	m	m	⅛	⅛	140	⅛	⅛	0	0	0
½	m	m	½	½	120	⅛	¼	⅛	0	0
½	⅛	m	1½	½	100	½	½	¼	½	¼
½	¼	m	1½	½	80	½	½	½	¼	¼
¼	¼	m	½	⅛	60	¼	¼	¼	¼	m

A, mid-thigh, normal oscillation from 6 divisions up.
B, mid-calf, normal oscillation from 4 to 6 divisions.
C, ankle, normal oscillation from 2 to 4 divisions.
D, upper arm, normal oscillation from 6 divisions up.
E, forearm, normal oscillation from 3 divisions up.
*Barely perceptible oscillation.

The examination indicated, therefore, marked dilatation of the pulmonic artery proximal to the region of the bifurcation, with prolonged opacification. This is encountered in association with a patent ductus arteriosus. It is possible that the slight dilatation of the base of the aorta is to be interpreted as indicating a slight narrowing of the descending aorta in the region of the patent ductus.

*We wish to thank Dr. M. L. Sussman, Director of the X-Ray Division of the Mount Sinai Hospital, New York City, for this report.

The electrocardiogram revealed right axis deviation.

The oscillometric readings revealed a markedly diminished amplitude in the left arm and both lower extremities (Table II).

Skin temperatures which were obtained at a room temperature of 65.5° F. showed a significant difference between the upper and lower extremities, as well as between the arms.

The injection of histamine produced a uniform flare in all four extremities.

The blood Wassermann reaction was negative.

Comment.—In the case of a boy, aged 9 years, a diagnosis of coarctation of the aorta, with involvement of the left subclavian artery, was made in the presence of a widely patent ductus arteriosus. Evidences of collateral circulation were absent. Ligation of the duct was not attempted because of the associated cardiac complications.

DISCUSSION

The pathology and pathogenesis of stenosis of the isthmus of the aorta have been amply discussed by Blackford,[5] and others, who have concluded that the constriction of the arch is a prenatal malformation, to which there is added at birth the mechanical traction resulting from closure of the ductus arteriosus. The deformities of the subclavian arteries, such as the total absence or diminution in the caliber of the vessels, or a constriction of their orifices, very likely develop at the same time as the narrowing of the arch of the aorta. From the few cases reported to date it would appear that the left subclavian artery is the one more commonly involved[6-15] (Table III). The occasional presence of right-sided involvement of the subclavian artery, whose site of origin from the aorta is quite a distance from the arterial insertion of the duct, as well as the persistent patency of the duct (Case 2) which is found in some cases, supports the theory of the prenatal origin of these abnormalities, independent of the traction resulting at birth from the involution of the ductus arteriosus.

Obviously, when the right subclavian artery is implicated, the clinical manifestations are the reverse of those found with coarctation of the aorta and involvement of the left subclavian artery. The increase in pressure in the collateral vessels proximal to the constriction of the aorta and the left subclavian artery results in a series of clinical phenomena that should be particularly searched for if the diagnosis of this lesion is to be established early in life.

Asymmetry of the Body and Overgrowth of One Limb in Coarctation of the Aorta With Involvement of the Left Subclavian Artery.—Both of these children had an asymmetrical development, with overgrowth of the muscular and bony portions of the right upper half of the thorax and right arm, together with a congenital malformation of the heart. A careful search of the more recent literature revealed exceedingly few conditions that may be responsible for such maldevelopments. Schabad[16]

TABLE III

OBSERVATIONS ON REPORTED CASES OF COARCTATION OF THE AORTA, WITH IMPLICATION OF THE LEFT SUBCLAVIAN ARTERY

AUTHOR	YEAR REPORTED	AGE (YR.)	SEX	RIGHT RADIAL PULSE	LEFT RADIAL PULSE	FEMORAL PULSES	BLOOD PRESSURE		ROENTGENOGRAPHIC OBSERVATIONS	NECROPSY FINDINGS			
							RIGHT ARM	LEFT ARM		AORTA	LEFT SUBCLAVIAN ARTERY	RIGHT SUBCLAVIAN ARTERY	AORTIC VALVES
Lesseliers[6]	1882	20	F	Palpable	Feeble	Feeble				Uniform constriction	Atrophied and obstructed by peduncle		Bicuspid valve
Deneke[7]	1925	46	M	Full	Absent	Absent	185/85	0	Narrowing of aorta in right oblique position				
Woltman and Shelden[8]	1927	20	M	Full	Diminished	Diminished	164/86	126/110		Constriction at ductus	Aberrant cordlike structure		
Turkington[9]	1929	23		Full	Indistinct	Absent	210/110	130/80					Loud blowing diastolic murmur

Shatzki and Hallerman[10]	1930	15	M	Full	Diminished	Absent	185/140	135/90	Prestenotic and aneurysmal dilatation in left oblique position				
Ratschow and Arendt[11]	1934	31	M	Palpable	Absent	Diminished	150/65	80/55	Right-sided scalloping of ribs 6 to 9				
Parker and Dry[12]	1938	26	M	Large	Hardly palpable	Absent	210/40	100/78	Right-sided scalloping of ribs	Constriction at ductus	Abnormally small		Bicuspid valve
Bayley and Holoubek[13]	1940	32	M	Forceful	Absent	Palpable	154/78	98/78	Right-sided erosion of ribs				
Observations on Reported Cases of Coarctation of the Aorta, With Implication of the Right Subclavian Artery													
East[14]	1932	44	F							Constriction below the duct		Aberrant	
Love and Holmes[15]	1939	44	M				150/90	210/95		Constriction of isthmus		Abnormal origin; narrowed	

reported a 9-year-old boy with asymmetry of the arms and intense cyanosis of the entire body who suffered from recurrent attacks of syncope and shortness of breath. The length of the right arm from the acromion process to the tip of the middle finger was 54.2 cm., and that of the left arm was 52.4 cm. The control differences in the average child were found to be only 0.2 to 5 cm. There was a large pulsation over the pulmonic artery, and a systolic murmur which was continuous with a loud diastolic murmur (machinery murmur) was audible over the chest. The blood pressure (obtained with a Riva Rocci instrument) was 83 in the right arm and 73 in the left. Sphygmograms revealed that the apex of the curve on the left was lower than that on the right. Although no mention was made of the femoral pulses in this boy, it is very likely that he had coaretation of the aorta, with a widely patent ductus, in which the orifice of the left subclavian artery was involved.

In a cyanotic infant, aged 9 months, who showed clubbing of the fingers and toes and was suspected of having a congenital heart lesion, Scott[17] found a nevus 1 cm. in diameter on the right shoulder. There was atrophy of the entire left side of the body, including the skull, left arm, and left leg. The fact that this child's mother had a similar hemiatrophy suggests that the condition in the infant was the result of a cerebral lesion, rather than the effect of malformation of the vessels at the base of the heart.

Chandler[18] described local overgrowth of the left arm, with a congenital deformity of the left hand, in a colored boy whose teleoroentgenogram revealed marked enlargement of the left side of the base of the heart in the form of an aneurysmal dilatation. Unfortunately, no mention was made of the blood pressure readings or the pulses in the lower extremities.

Chandler pointed out that arteriovenous fistulas, vascular nevi, hemangiomas, and lymphangiomas may cause overgrowth of an extremity, if there is faulty development of the vascular tree in the fourth week of embryonic life. To these may be added the overgrowth of an arm resulting from circulatory changes caused by cervical ribs. The extremity affected shows an overgrowth of all elements, and the surface of the skin has a distinct elevation of temperature. In some cases the venous pressure is increased, and hypertrophy of the heart may result. All of these conditions may be easily distinguished from coaretation of the aorta, in which there are diminished blood pressure and force and strength of the pulsations in the lower extremities.

An instance of atrophy of the left arm, with congenital heart disease, was described in a 3-week-old infant who presented a left upper extremity that had been pale and cyanotic from birth and in which the pulse could not be obtained. At necropsy there was an overriding aorta, with a defect of the membranous portion of the interventricular septum.

In the upper part of the ductus there was a thrombus which extended into the ascending aorta, and into the lumen of the left common carotid, subclavian, axillary, and brachial arteries.[19]

The Blood Pressure in Coarctation of the Aorta, With Special Reference to the Differences in the Arms.—The elevation of the arterial blood pressure in the arms, as contrasted with the absent, diminished, or lowered arterial blood pressure in the femoral arteries, has been emphasized as a sign associated with coarctation of the aorta. From a study of this subject, King[20] has suggested a modification of the general opinion that the presence of hypertension affords the most important clue to isthmus stenosis. In a review of the blood pressure readings in all the cases of coarctation of the aorta reported between 1892 and 1936 in which such records were obtainable, he found 146 cases in which there were definite hypertension in one or both arms and a comparatively lower pressure, with feeble pulsations, in the legs. In fifty-six of these cases the average pressure in the right arm was found to be 190/92, and that in the left arm, 185/94. Such slight differences in the pressure in the arms have been noted in previous reports, and have been attributed to a slowing of the blood stream as it passes the mouth of the left subclavian artery when there is a narrowing of the aorta distal to it.

In ten other cases, however, five of which have been mentioned above, and in those of Amberg,[21] Hersdoffer,[22] and Villafane and Menendez,[23] King called attention to a wider difference in the blood pressure in the arms; that in the left arm was substantially lower than that in the right. Similar observations were reported recently by Borgard[24] and Hills[25] in two cases of coarctation of the aorta. The suggestion has been offered by the latter observers that such radical differences in the blood pressure in the arms must inevitably be the result of a constriction or obstruction of the orifice of the left subclavian artery. The total absence of a blood pressure reading in the left arms of the two children reported in this study lends further support to this contention.

The Disparity in the Strength and Force of the Pulsations of the Two Radial Arteries.—A difference in the size and force of the pulsations in the two radial arteries was regarded by the older clinicians as a sign of coarctation of the aorta, but only a few considered this as evidence that the constriction of the isthmus also involved the origin of the left subclavian artery. Erman[26] noted this difference in a 19-year-old boy who developed a left-sided hemiplegia. On some days the left radial pulse would be totally absent, but pulsations could be felt in the left brachial artery. However, at necropsy the diameters of both subclavian orifices were found to be the same. In Schichold's[27] 32-year-old servant girl, the left pulse was not only smaller than the right, but was also observed to lag behind the femoral pulsations, yet necropsy revealed that the orifice of the left subclavian artery was larger than the right. Hochsinger[28] suspected coarctation of the isthmus in a 13-year-old boy who

had no femoral pulsations, but showed marked pulsations of the right subclavian and the left carotid arteries, and a left radial pulse which was half as large as the right.

Brown[29] diagnosed congenital stenosis of the aorta in a man, aged 27 years, in whom he thought the abnormality in some way involved the orifice of the left subclavian artery, for the right subclavian artery was large and pulsated forcibly, whereas the left was extremely small and its pulsations were very faint. In Stürsberg's[30] patient, the pulsations of the left subclavian, brachial, and radial arteries were smaller than those on the right side. The blood pressure (obtained with a Riva Rocci instrument) was 102 in the right arm and 77 in the left. In slow sphygmographic curves he was able to demonstrate that there was no actual delay of the ascending limb of the radial pulse in the left arm, as compared with that in the right, but that the apex of the pulse was weak, blunt, and retarded in the left radial; the occurrence of this phenomenon was confirmed by King[31] in his excellent study of the subject. The lagging of the left radial pulse, when it is diminished in force and volume, appears to be synchronous with that of the femorals. King felt that this distinct difference in the pulsations of the two radial arteries in patients with coaretation of the aorta was the result of the proximity of the orifice of the left subclavian to the narrowed portion of the isthmus. The momentary slowing of the blood stream in the aorta as a result of the stricture causes slow passage of blood over the orifice of the left subclavian artery, and this produces the type of pulse tracings described.

In the light of more recent observations, however, it must be conceded that, in some patients with coaretation of the aorta, an actual diminution of the volume of blood flow in the left subclavian artery causes the pulse differences in the two arms. Nevertheless, this sign in itself, although very suggestive, cannot be taken as a criterion of involvement of the orifice of the subclavian artery because of the inconsistent necropsy observations.

Differences in the Force and Strength of Pulsation Between the Upper and Lower Extremities.—A recent summary of all the cases of children with coaretation of the aorta which have been reported to date convinced Eisenberg[32] that a disparity of force and strength of pulsation between the radial arteries and the abdominal and femoral vessels is of the greatest importance in the recognition of a narrowing of the isthmus, no matter what accompanying conditions may be present in the heart. Hamilton and Abbott[33] considered retardation and diminution, or even absence to the palpating finger, of the femoral pulse as pathognomonic of coaretation. They pointed out, however, that in adults this sign may not be constant, either as to its presence or as to the extent of the diminution, which seems to bear no relationship to the degree of stenosis. Uniform diminution of the oscillographic readings in both

lower extremities, as compared with the upper limbs, is of greater value when there is doubt about the diagnosis in children.

The Roentgenologic Diagnosis of Coactation of the Aorta Involving the Orifice of the Left Subclavian Artery.—In children with coarctation of the aorta, a superficial collateral circulation over the back, such as is found in adults, is seen only rarely. However, an internal collateral circulation must certainly exist, and evidence of this may at times be detected in roentgenograms of the chest (Fig. 2). This consists of erosion along the lower margins of the ribs posteriorly, usually on both sides of the chest. The defects may be multiple, affecting more than one rib, and not infrequently may produce multiple defects in the same rib.[34]

In patients with coarctation of the aorta involving the left subclavian artery, the erosion of the ribs, when present, is found on the right side only. The extent of the rib erosion in such cases will depend on the degree of constriction of both the aorta and the left subclavian artery, in the *absence* of a widely patent ductus arteriosus. This accounts for the absence of rib erosion in our second case.

Other roentgenologic evidences that may be of help in the recognition of coarctation of the aorta are absence of the aortic knob in the antero-posterior view, a prestenotic aneurysmal dilatation of the aorta proximal to the constriction, dilatation of the aorta distal to the narrowing, and failure to visualize the aortic continuity in the left oblique position. Often, in this position, there is an actual absence of the aortic shadow where it narrows down, so that it cannot be seen at all in that region (Fig. 3).

Enlargement of either the left or right ventricle will depend more on the accompanying valvular lesion than on constriction of the arch. A large left ventricle may be expected with aortic insufficiency, which is usually due to infection of a bicuspid valve (found in 25 per cent of cases) with the *Streptococcus viridans*. Enlargement of the right ventricle occurs when the ductus arteriosus is widely patent. At times a fullness in the right hilar region, with a more pronounced dilatation of the vessels on the right side, may help to detect obstruction of the left subclavian artery.

The likelihood that diodrast studies can delineate the subclavian arteries should be thought of when searching for absence of the vessel, for a large subclavian artery on the left side may be easily visualized with this method.[35]

SUMMARY AND CONCLUSIONS

The clinical signs associated with coarctation of the aorta which involved the origin of the left subclavian artery were studied in two children.

Both children had an asymmetrical development of the upper half of the body; the right half of the chest was larger than the left, and the right upper arm was longer, and larger in circumference, than the left.

Both children had no pulsations in the left axillary, brachial, and radial arteries. At times they had a diminished pulsation of the left carotid artery.

The blood pressure was obtainable in the right arm only. It was elevated in one child and within normal limits in the other.

In one child with aortic insufficiency, a roentgenogram of the chest revealed sulci and grooves in the caudad portions of the posterior portions of the ribs on the right side only. In the second child, who had a widely patent ductus arteriosus, there was no collateral circulation.

The pulsations of the abdominal and femoral vessels were absent, or retarded, or diminished in volume, and this was confirmed by oscillographic readings.

Coarctation of the aorta, with involvement of the orifice of the left subclavian artery, should be easily suspected in the presence of such abnormalities.

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AN IMPROVED BLOOD PRESSURE CUFF

WILLIAM S. COLLENS, M.D., AND LOUIS C. BOAS, M.D.
BROOKLYN, N. Y.

IT HAS undoubtedly been the experience of every man in clinical practice that, in taking a blood pressure reading, especially on obese persons with large arms, the cuff has a tendency to slip out and "herniate" from the restraining binder as it is progressively inflated. The

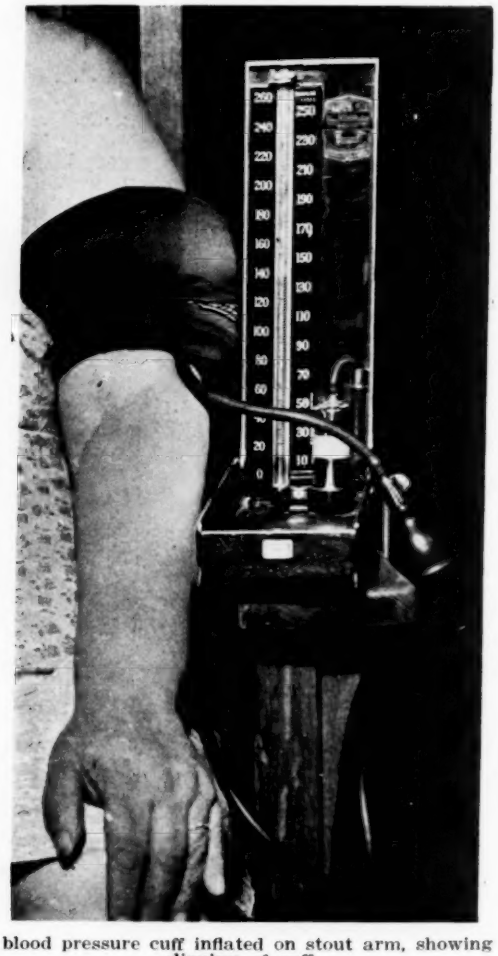

Fig. 1.—Standard blood pressure cuff inflated on stout arm, showing "herniation" and slipping of cuff.

From the Metabolic Clinic, Israel-Zion Hospital.
Received for publication April 7, 1941.

restraining binder then acts as a cordlike band which frequently produces pain at the site of constriction. The herniation of the rubber bag and the pain are factors in producing false readings.

Fig. 2.—Improved cuff with same degree of inflation.

We have devised a cuff which eliminates this difficulty. The rubber bag is constructed in such a fashion that its outer wall is inelastic. The physician can easily improve the ordinary cuff which he is at present employing by cementing a piece of canvas to the outer portion of the rubber bag, thus destroying its elasticity. Blood pressure measurements made with the new cuff and with the old type, when no herniation occurs, have been found to be identical. We have arranged with a manufacturer* to market this improved cuff at the same price as that of the present standard cuff.

123 Eighth Avenue

*U. M. A. Co., 111 Greene Street, New York City.

A DEVICE FOR OBTAINING ELECTROCARDIOGRAPHIC LEADS FROM THE PRECORDIUM

M. S. WHITE,* M.D.
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AN INSTRUMENT was devised to obtain precordial leads by the various recommended methods, as well as the standard leads, without changing lead wires or electrodes during the process. It has been arranged so that several patients may be connected in succession to a single electrocardiograph at a rapid rate, as may be required in certain investigations or in the examination of large groups.

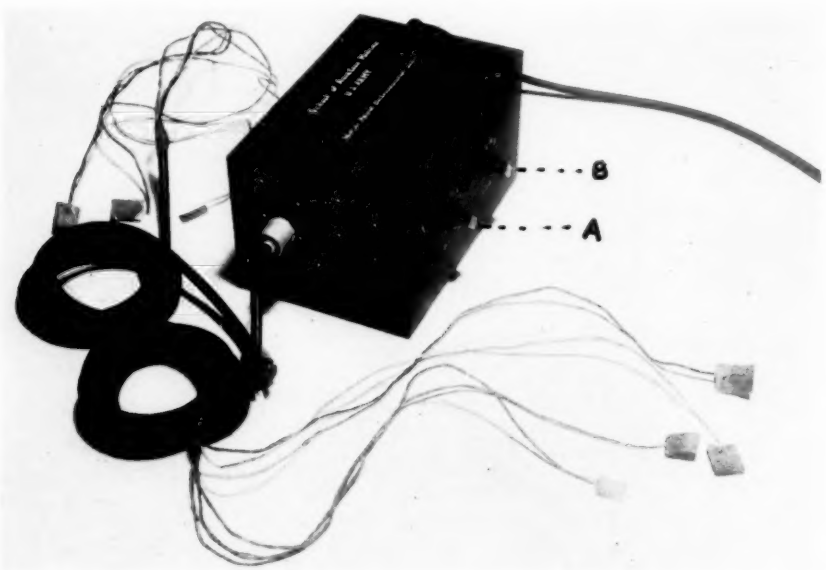

Fig. 1.—Exterior view of multiple patient-switch box. *A*, Patient selector switch; *B*, Lead selector switch.

DESCRIPTION OF DEVICE

To each patient four electrodes are attached—three to the usual extremities and one to the precordium. Each electrode is connected to a prong of a four-prong polarized plug by a four-conductor cable. Any number of patients (in this case, four) may be so connected. Each plug is inserted into a polarized jack on the left-hand side of the switch box. This switch box has two control switches. The

From the School of Aviation Medicine, Randolph Field, Texas.
Received for publication May 12, 1941.
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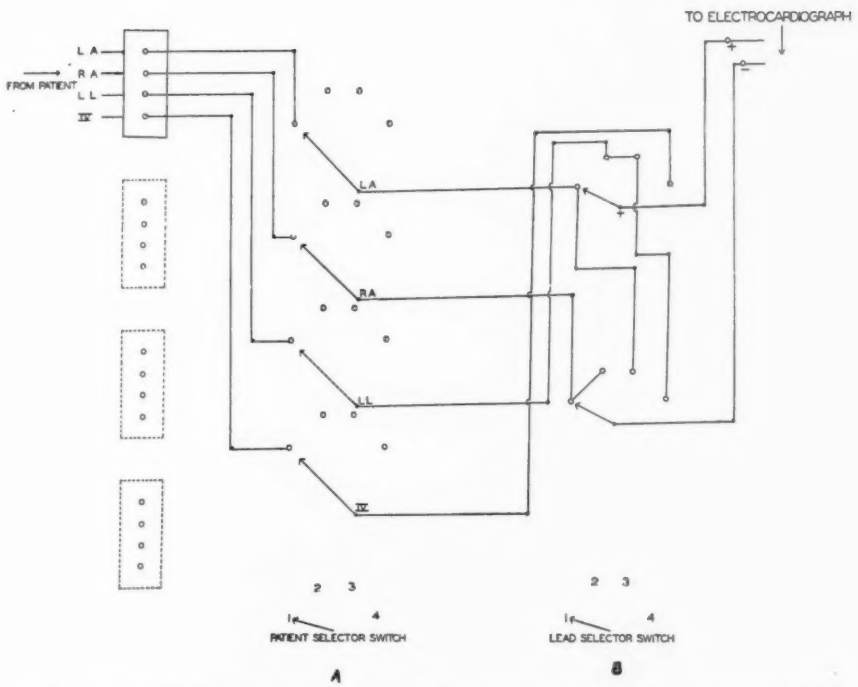

Fig. 2.—Wiring diagram of multiple patient-switch box. *LA*, to left arm; *RA*, to right arm; *LL*, to left leg; *IV*, to precordium.

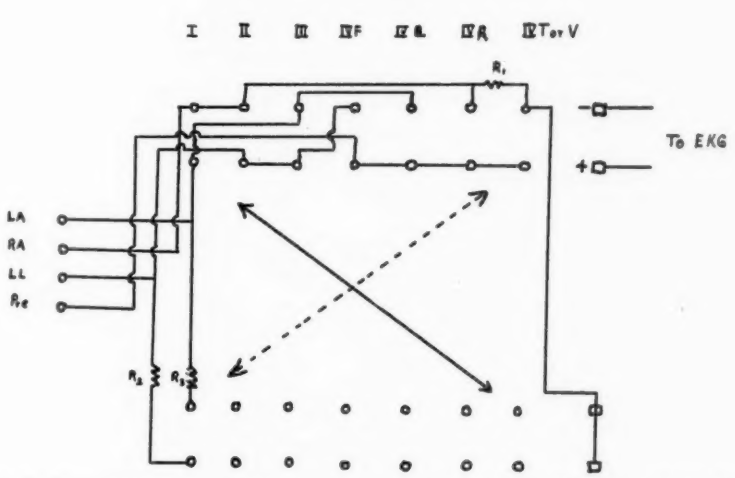

Fig. 3.—Precordial lead switch for one patient. Wiring diagram. Solid line of switch indicates position for obtaining Lead I. Broken line of switch indicates position for Lead IVT. Resistances shown (R_1, R_2, R_3) are 5,000 ohms each. Intermediary positions of the switch will select any of the remaining leads indicated on the diagram without changing lead wires or position of electrodes.

first of these (*A*, Figs. 1 and 2) selects the patient whose record is to be taken at the moment. The second switch (*B*, Figs. 1 and 2) selects any one of the four leads which it is desired to record from that patient. On the right-hand end of the switch box there is a polarized jack into which is inserted a plug connected to two wires leading directly to the electrocardiograph. Any two lead wires of the electrocardiograph may be connected to the plug, with due regard to polarity. The corresponding lead is then selected by the lead switch on the control panel of the electrocardiograph.

The switches of the instrument are simple selector-switches, such as are used in the band switches of radio receivers. Inasmuch as thirty contact points can be obtained, with due regard to polarity, they can be adapted for any number of patients or leads desired.

The wiring diagram (Fig. 2) shows the arrangement for obtaining the three standard leads and Lead IVF. When used for one patient only, by simple additional connections, as shown in Fig. 3, the device can be arranged so that one-step movements of the switch will select the following precordial leads: IVF, IVR, IVL, or IVT. Lead IVT is obtained by adding the zero-potential electrode of Wilson to the circuit.

Because of the ease with which any special precordial lead may be obtained with this instrument, the argument that some one precordial lead should be used because it is easier to record than the others is no longer tenable.

Department of Clinical Reports

VENTRICULAR TACHYCARDIA OF UNUSUALLY LONG DURATION (SEVENTY-SEVEN DAYS)

ALEXIS T. MAYS, M.D.
BROOKLYN, N. Y.

VENTRICULAR tachycardia usually starts suddenly and terminates abruptly. The attacks last variable periods of time, usually minutes to hours, occasionally for days, and, on very rare occasions, a week or more. Long-continued attacks of ventricular tachycardia are rare, and are usually fatal. Wolferth and McMillan[1] reported four cases of paroxysmal ventricular tachycardia, and reviewed twenty-two cases from the literature, with electrocardiographic proof; the longest paroxysm persisted eleven days. Porter[2] reported an attack which lasted 153 hours, with recovery. Levine and Fulton[3] described an attack of fourteen days' duration which resulted in death. Salley[4] reported an attack which lasted eleven days and terminated in death. Elliott and Fenn[5] reported a ventricular tachycardia of thirty-two days' duration which resulted in death. Strong and Munroe[6] presented an unusual case of an attack which lasted twenty-three days, with recovery.

A patient who was admitted to the Methodist Hospital with ventricular tachycardia is of interest because of the unusually long duration of the attack; it lasted seventy-one days in the hospital, and probably began six days before admission, making a total of seventy-seven days.

CASE REPORT

A 59-year-old Polish cabinetmaker entered the hospital March 3, 1939, complaining of marked shortness of breath and a rapid heart; the symptoms began suddenly February 25, and were induced by excitement at a Union meeting. His doctor prescribed digitalis and bed rest. Several days later he complained of severe upper right abdominal pain, vomiting, and persistent hiccough. Six days after the onset he was brought to the hospital in an ambulance. Three years previously he had had a similar attack while walking a long distance and after a large meal, and remained in bed for two weeks. He continued his usual work until May, 1938, when he experienced another attack of rapid heart beating while dancing; this persisted for one month. From that time he complained of marked fatigue and dyspnea and palpitation while walking and working at his trade.

On admission he was very orthopneic, with an anxious expression, was moderately pale and cyanosed, and was hiccoughing continually and perspiring profusely. His

From The Medical Service, Methodist Hospital, Brooklyn, N. Y.
Received for publication Oct. 5, 1940.

weight was about 140 pounds; his temperature, 101.2° F. The eyes, nose, and throat showed no abnormalities. The external jugular veins were markedly distended, with questionable pulsations. Arterial pulsations were marked over each clavicle. The cervical lymph nodes and thyroid gland were not enlarged. The respiratory rate was 40 per minute. The apex beat was faintly palpable in the fifth intercostal space, halfway between the midclavicular and anterior axillary lines. The heart sounds were faint at the apex. The rate was 200, and the beating was regular. A fairly loud pericardial friction rub was heard in the fifth intercostal space at the parasternal line. No murmurs were audible. The blood pressure was 100/80. There was dullness at the bases of both lungs, with diminished breath sounds and crepitant râles, especially on the right side. The liver extended two fingerbreadths below the costal margin. There were marked distention and pulsations of the superficial arm veins, which remained distended when the arms were raised above the angle of Louis. The pulse volume was small. There was no edema of the legs or ankles.

Diagnosis on admission was enlarged heart, coronary artery thrombosis, auricular flutter, and congestive heart failure.

Digifoline (30 minims), morphine, Hoffmann's anodyne and carbogen were administered. An electrocardiogram showed ventricular tachycardia (Fig. 1). The patient was given quinidine sulfate in a dose of 3 grains every four hours; this was increased to 36 grains a day the following day. The erythrocyte count was 4,240,000, the hemoglobin, 13.6 Gm., and the leucocyte count, 22,900; 87 per cent of the leucocytes were polymorphonuclears. Chemical examination of the blood disclosed the following (in mg. per cent): nonprotein nitrogen, 40; sugar, 103; uric acid, 3.5; creatinine, 1.2; cholesterol, 174; chlorides, 410; calcium, 9.8; and phosphorus, 3.8. The CO_2 combining power was 44.3 volumes per cent. The blood Wassermann and Kahn reactions were negative. The sedimentation time was 20 minutes. Urinalysis was negative. Roentgenologic examination showed cardiac enlargement of the aortic and mitral type, with marked congestion of the bases of both lungs.

During the first 2.5 weeks the temperature averaged about 100° F., and gradually became normal during the third week; at the same time the leucocyte count gradually fell to 12,750 and the polymorphonuclears to 76 per cent, and the sedimentation time increased to two hours.

Nine grains of quinidine sulfate were given on the first day and 36 grains a day for the next five days. Daily electrocardiograms showed slowing of the ventricular rate to 140 on the seventh day; the duration of QRS remained at 0.16 sec. On the fifth day, 1/150 grain of atropine sulfate was administered with each dose of quinidine without change in rhythm. Quinidine was discontinued on the seventh day, and 0.5 gm. of quinine dihydrochloride was given intravenously. An electrocardiogram showed an increase in the ventricular rate to 158 and a QRS duration of 0.18 sec., but no change in the abnormal rhythm.

On the eighth day, 10 mg. of acetyl-beta-methylcholine chloride (mecholyl) were administered subcutaneously, accompanied by carotid sinus pressure. An additional 10 mg. which were given three minutes later produced a slight reaction. The electrocardiogram showed an increase in the ventricular rate to 176, but no change in rhythm.

The following day 30 mg. of mecholyl were given; this was followed by a fairly marked reaction, but no change in rhythm. The ventricular rate increased to 180. A few hours later signs of heart failure appeared, and 1.5 grains of digitalis were given orally every four hours during the next twenty-four hours; the electrocardiogram then showed an increase in the ventricular rate to 187, with a QRS of 0.16 sec.

On the eleventh day a second injection of 0.5 Gm. of quinine dihydrochloride was given, without reaction or change in rhythm. Quinidine sulfate in a dose of 36 grains a day was resumed, and, on the following day, the electrocardiogram

showed that the ventricular rate had diminished to 167, and there were fewer signs of heart failure. Since the heart rate diminished with quinidine therapy, the dose was increased to 72 grains a day, and three days later an electrocardiogram showed a ventricular rate 115 and a QRS duration of 0.22 sec. At this time the patient felt improved and had less pronounced signs of heart failure. Atropine sulfate in a dose of 1/50 grain was given subcutaneously on two occasions, together with 12 grains of quinidine, but no change in rhythm occurred.

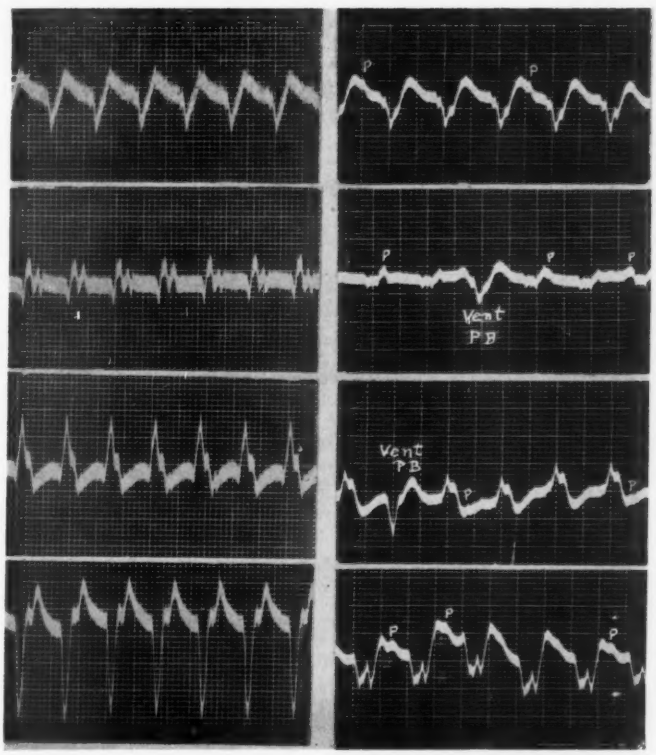

Fig. 1. Fig. 2.

Fig. 1.—Ventricular tachycardia, rate 187, QRS 0.16 sec.
Fig. 2.—Ventricular tachycardia, rate 150; a ventricular premature beat is shown in Leads II and III. Questionable P waves in all leads.

On the sixteenth day the quinidine was reduced to 36 grains a day, and during the next three days the ventricular rate increased to 167.

During the night of the twentieth day, the patient was awakened by a choking feeling and rapid beating of his heart. No new abnormal physical signs were found. Morphine gradually relieved the attack. An electrocardiogram showed the same rhythm, with a ventricular rate of 167. The quinidine was increased to 54 grains a day, and, during the next three days, the ventricular rate diminished to 136, with a QRS duration of 0.20 sec.

During the fourth week the temperature remained normal and the patient was allowed a back rest. Quinidine in a dose of 54 grains a day was continued; the heart rate varied from 110 to 125, and the QRS duration, from 0.20 to 0.22 sec.

On the thirty-second day quinidine was discontinued, and 20 c.c. of a 10 per cent solution af magnesium sulfate were administered intravenously. Two minutes later the patient complained of a "burning feeling," perspired profusely, appeared pale,

became very apprehensive, and had a marked acceleration of respiration. Calcium chloride controlled the reaction. An electrocardiogram showed no change in rhythm and a ventricular rate of 130; QRS measured 0.20 sec. Quinidine sulfate in a dose of 60 grains a day was resumed, and the ventricular rate varied from 130 to 136 during the next six days.

On the thirty-eighth day a fluttering sensation around the heart became very annoying, and signs of pulmonary edema were found. Enlargement of the liver and edema of the ankles followed. The electrocardiogram showed ventricular tachycardia at a rate of 136, but with very low amplitude of the QRS deflections and T waves. Quinidine was discontinued. Digitalis (total dose 22.5 grains) was administered over a period of four days, with marked diminution of the pulmonary edema, congestion of the liver, and edema of the legs. The electrocardiogram showed an increase in the ventricular rate to 167, with persistence of the ventricular tachycardia. Quinidine in a dose of 36 grains a day was resumed, and the ventricular rate diminished to 150 after two days.

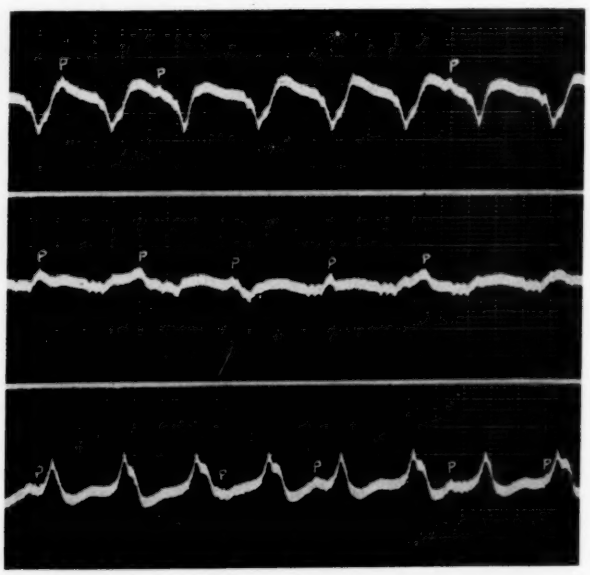

Fig. 3.—Immediately after an intravenous injection of 10 grains of quinidine. Ventricular tachycardia, rate 115. QRS 0.20 sec. P waves present in all leads.

On the forty-ninth day the quinidine was discontinued and mecholyl repeated. Thirty milligrams were injected subcutaneously, and twenty minutes later an additional 20 mg. were administered. A marked reaction followed, but no change in rhythm occurred. An electrocardiogram showed ventricular tachycardia, with a rate of 150.

On the fiftieth day 0.0005 Gm. of scillaren was administered intramuscularly, and one hour later the patient complained of a severe tight sensation across the anterior part of the chest. An electrocardiogram showed ventricular tachycardia, with a rate of 176. Thirty-six grains of quinidine and 120 grains of potassium bromide were given, and, on the following day, the electrocardiogram showed that the ventricular rate had been reduced to 136.

On the fifty-second day the patient developed an infarction in the lower lobe of the right lung. Morphine was required to relieve the pain and discomfort. The quinidine and potassium bromide were continued, and, in addition, a 50 per

cent solution of glucose was given intravenously twice a day. Daily electrocardiograms showed a gradual increase in the ventricular rate to 150, with occasional ventricular premature beats and questionable P waves (Fig. 2).

During the fifty-fourth day the patient became more apprehensive and restless, and had Cheynes-Stokes breathing. The apex beat was easily palpable in the sixth intercostal space at the anterior axillary line. The heart sounds were very faint and rapid. No murmurs were audible. The rhythm was occasionally irregular. Bilateral hydrothorax was present, and the liver was enlarged to the umbilicus. Marked edema extended up to the lower thighs. Mercurpurin intravenously had no effect. Coramine was given for several days with no beneficial results. The patient had been taking 36 grains of quinidine daily, and the ventricular rate varied from 120 to 136.

On the fifty-ninth day, 6 grains of quinidine sulfate were dissolved in 100 c.c. of physiologic saline solution and given intravenously over a period of twenty minutes. During the injection the respirations increased in depth and rate, and this was followed by nausea. Five hours later 10 grains more were injected, with occurrence of the same symptoms. An electrocardiogram made immediately after the injection showed ventricular tachycardia, a rate of 115, and a QRS duration of 0.20 sec. P waves were present at a slower rate (Fig. 3).

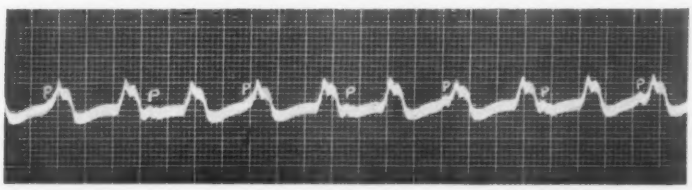

Fig. 4.—Lead III. After intravenous injection of 10 grains of quinidine. Ventricular tachycardia, rate 125, QRS 0.18 sec. P waves shown at the rate of 83 per minute.

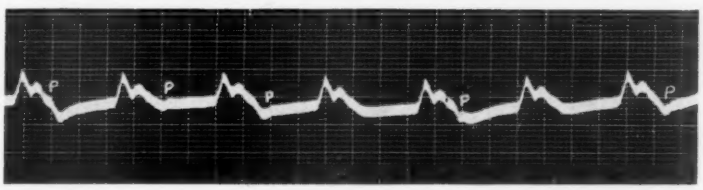

Fig. 5.—Lead III. After intravenous injection of 12 grains of quinidine. Ventricular tachycardia, rate 84, QRS 0.28 sec. P waves shown at slower and irregular intervals.

During the following week 36 grains of quinidine were given daily by mouth. The patient also received 120 grains of potassium bromide a day, 100 c.c. of a 50 per cent solution of glucose intravenously twice a day, and an occasional dose of morphine. The electrocardiograms showed continuous ventricular tachycardia, with occasional questionable P waves in the QRS groups and on the base line. The ventricular rate increased from 125 to 136.

On the morning of the sixty-ninth day, 10 grains of quinidine sulfate were dissolved in 100 c.c. of sterile distilled water and given intravenously by the drop method, over a period of fifty minutes. An electrocardiogram after the injection showed no change in rhythm, but an increase in the rate to 125. P waves were present with a slower (rate 83), regular rhythm (Fig. 4).

Four hours later another intravenous injection of 12 grains of quinidine sulfate was almost completed by the same method when the patient suddenly became unconscious and pulseless. The electrocardiogram at this time showed ventricular

tachycardia, with a rate of 84; the duration of QRS was approximately 0.28 sec. P waves were noted at a slower rate and at irregular intervals (Fig. 5).

Seven minims of adrenalin were injected subcutaneously, but the patient did not regain consciousness until thirty minutes later. One minute after the injection of adrenalin the ventricular rate increased to 100, and, in two minutes, the rate increased to 125, where it remained until he regained consciousness. Electrocardiograms made during this time continued to show ventricular tachycardia. During the next twenty-four hours the patient became steadily worse. An electrocardiogram showed ventricular tachycardia, with a rate of 136 and a QRS of 0.16 sec. The heart sounds became very faint, with signs of heart failure. Pulmonary edema occurred early the next morning, and the patient expired.

Fig. 6.—Marked enlargement of the heart, showing the dilated and thin left ventricular wall at the apex region. The large, lighter area, involving more than half of the wall and interventricular septum, shows the extent of the dense fibrosed infarct resulting from thrombosis 1 cm. from the opening of the left coronary artery. The orifices of both coronary arteries are patent.

Post-Mortem Examination.—The heart weighed 540 Gm. (Fig. 6). The epicardium was transparent and glistening. The apex was enlarged and rounded, with a very thin wall. The left ventricular cavity was 10 cm. long, and was filled with old and new blood clots. The upper ventricular wall was firm, and measured 1.2 cm. At the apex the wall measured 3 mm., and consisted of epicardium, endocardium, and a thin layer of fibrous tissue. A section cut 1 cm. below the aortic valve showed streaks of fibrous tissue extending throughout the entire width of the septum. The papillary muscles appeared normal. The right auricle was markedly dilated. The valve orifices were of normal diameter, and the valves showed no lesions. The mouth of the left coronary artery was patent, and the first centimeter of the vessel was normal. The next centimeter was markedly thickened and calcified, and calcified plaques occluded the lumen. The right coronary artery was patent and had a thin and pliable wall. The aorta measured 7 cm. in the circumference, and showed a few small yellowish areas.

The right pleural cavity contained 1,500 c.c. of clear yellow fluid. The right upper lobe showed diffuse consolidation. The right lower lobe contained an infarct 5 cm. in diameter, and a smaller infarct, 3 cm. in diameter, was found in the left lower lobe. The pulmonary vessels and hilar nodes were normal.

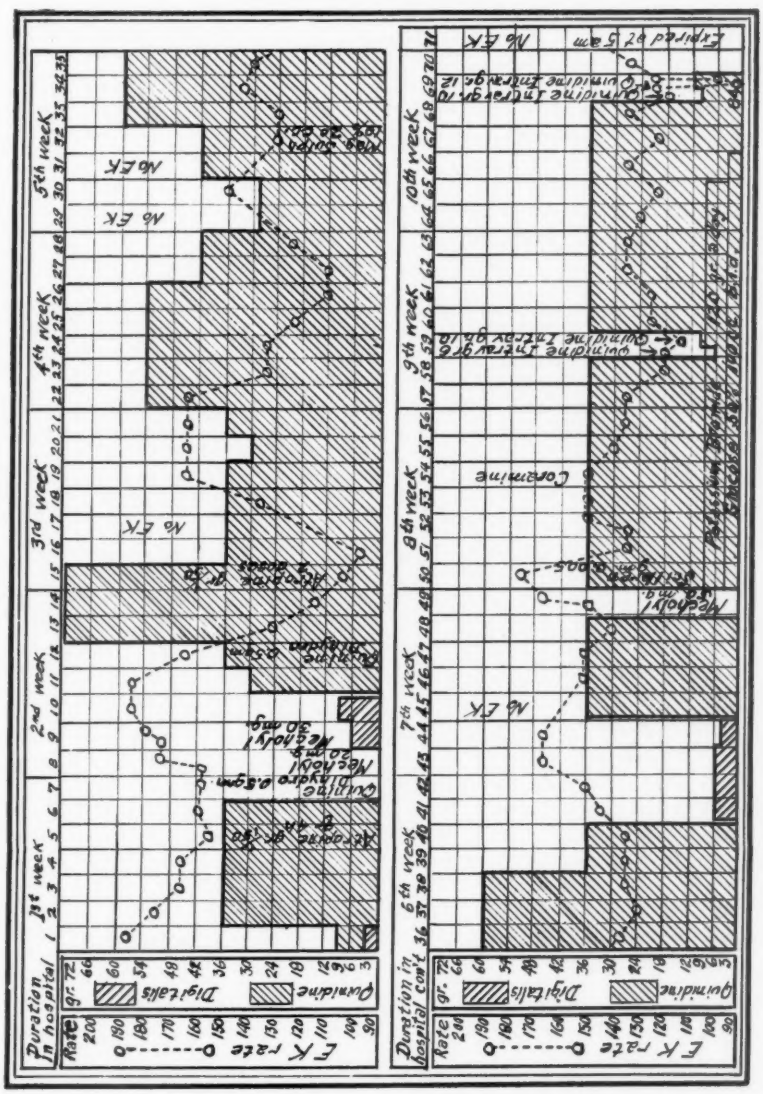

Fig. 7.—The effect of drugs during treatment in hospital. Ventricular tachycardia of unusually long duration.

The liver weighed 1,540 Gm. The gall bladder, spleen, pancreas, and adrenals were normal. An infarct 5 cm. in diameter was found in the right kidney.

Microscopic examination of a section from the apex showed that practically all of the myocardium had been replaced by dense, almost acellular, fibrous tissue. Numerous large and small areas of fibrosis were found throughout the entire myocardium. A section of the septum showed areas of fibrous tissue. A cross section of the left coronary artery showed marked sclerotic thickening of the intima, with occlusion of the lumen.

DISCUSSION

Ventricular tachycardia is a serious cardiac disorder, and attacks of long duration are usually fatal. It has been suggested by Levine and Fulton that circus movement in the ventricle is the cause of ventricular tachycardia, and that this accounts for the slight irregularity of the ventricular complexes. Many cases of paroxysmal ventricular tachycardia during and following the administration of digitalis have been reported. Before admission to the hospital this patient received digitalis (exact amount not known), and, after admission, received 3 grains of digitalis before the first electrocardiogram was made. All forms of therapy failed to restore normal rhythm. Because of the increasing signs of heart failure, 22.5 grains of digitalis were administered; this was followed by lessening of the congestion, but the heart rate increased. Atropine in combination with quinidine did not alter the rhythm. Several injections of acetyl-beta-methylcholine chloride, with carotid sinus pressure, had no effect on the rhythm. Magnesium sulfate intravenously caused an alarming reaction which subsided after an injection of calcium; there was no effect on the rhythm. Two intravenous injections of quinidine dihydrochloride were given without reaction or change in rhythm, but they were followed by an increase in the heart rate. Large doses of quinidine sulfate made the patient more comfortable and could be relied upon to slow the ventricular rate until a few days before death, but never changed the rhythm. On the fifty-ninth day an intravenous injection of 6 grains of quinidine sulfate, followed by another of 10 grains, did not cause a marked reaction or change in rhythm, but another attempt to give quinidine intravenously caused a sudden and alraming reaction. The patient was revived with adrenalin. No further attempt was made to given medication intravenously because of the seriousiness of the patient's condition.

SUMMARY

This is the report of a case of coronary artery thrombosis, with infarction and involvement of the interventricular septum, marked enlargement of the heart, and dilatation of the left ventricular wall, complicated by ventricular tachycardia of seventy-one days' (known) duration.

Because of the sudden onset of a rapid heart rate, with marked dyspnea, immediately after undue excitement six days before entering the hospital, it is reasonable to assume that the ventricular tachycardia was continuous for seventy-seven days. The classical anginal syndrome was not conspicuous at the onset, but the presence of marked dyspnea, palpitation, and certain clinical signs led to the diagnosis of coronary artery thrombosis, with severe myocardial damage. The ventricular tachycardia was demonstrated by numerous, almost daily, electrocardiograms. Digitalis was given on two occasions in an attempt to control

the heart failure. The ability of large doses of quinidine sulfate to slow the ventricular rate was demonstrated. No form of treatment abolished this abnormal rhythm. The clinical, electrocardiographic, therapeutic, and post-mortem observations are reported.

I wish to express my indebtedness and appreciation to Dr. Harold E. B. Pardee for his helpful electrocardiographic interpretations, suggestions concerning treatment, and aid in preparation of this report.

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Department of Reviews and Abstracts

Selected Abstracts

Sabathie, L. G., and Pianetto, M. B.: The Coronary Arteries of the Horse. Rev. argent. de cardiol. **8**: 184, 1941.

In the horse, as in most herbivorous animals, the right coronary artery is much larger than the left. The sinus node has a double blood supply (from the left circumflex and the right coronary arteries). The Aschoff-Tawara node receives its blood supply from the posterior and superior septal arteries, branches of the posterior descending artery which also irrigates the His bundle. The bundle branches are irrigated by the anterior and posterior septal arteries.

The left coronary artery supplies the anterior half of the left ventricle, a region 4 cm. wide of the right ventricle adjacent to the anterior interventricular groove, all the left auricle but its posterior wall, a zone of the right auricle anterior to the orifice of the superior vena cava, and the anterior half of the interventricular septum.

The right coronary artery irrigates the right ventricle excepting the zone adjoining the anterior interventricular groove, the posterior half of the left ventricle, the right auricle excepting the zone anterior to the superior vena cava, the posterior wall of the left auricle, and the posterior half of the interventricular septum.

Both coronary arteries are connected by anastomosis.

AUTHORS.

Perlow, S., Killian, S. T., Katz, L. N., and Asher, R.: Shock Following Venous Occlusion of a Leg. Am. J. Physiol. **134**: 755, 1941.

In the course of experiments in which attempts were made to produce chronic edema the procedure of ligation of the iliac vein with injection of various materials distally into the vein was initiated. In a number of instances marked edema of the legs developed and the animals died within twenty-four hours, sometimes within four to six hours. The possibility of shock as the cause of death suggested itself, and this was investigated in a series of eight dogs.

Nearly complete venous occlusion of a hindlimb of the dog leads to shock which terminates fatally. This procedure offers a simple way of studying the course of shock and the utility of some of the proposed therapeutic agents to counteract shock.

The mechanism appears to be the marked loss of fluid into the leg, at first plasma and later whole blood, which amounts to from 4 to 6 per cent of the body weight. This loss is brought about first by an increase in the capillary hydrostatic pressure of the occluded limb soon aggravated by loss of capillary permeability. These experiments tend to support the view that the primary mechanism in shock is the local loss of fluid from the blood.

AUTHORS.

Wiggers, C. J.: Cardiac Adaptations in Acute Progressive Anoxia. Ann. Int. Med. **14:** 1237, 1941.

In acute progressive anoxia the supply of oxygen to cells is not conditioned solely by the degree of pulmonary ventilation and the oxygen-carrying capacity of the blood; it involves also an increased blood flow.

The circulatory reactions characteristic for man, breathing gas mixtures with decreasing oxygen volumes (20>6 per cent) can be duplicated in lightly anesthetized dogs. Such experiments have the advantage that the mechanisms by which cardiac adaptations operate to increase blood flow can be analyzed more thoroughly than in man.

During hypoxia, corresponding to progressive decrease in respired oxygen volumes to about 12 per cent, to blood oxygen saturations above 75 per cent or altitudes of 15,000 feet, blood flow is increased (a) regionally by reciprocal constriction and dilatation of vessels causing redistribution of blood flow and (b) generally by acceleration of the heart. The latter is due to decreased vagal tone, increased accelerator nerve activity, and perhaps some direct effect on the S-A node. Stroke volume is not affected otherwise than during any cardiac acceleration. The vigor of ventricular contractions increases, and the period of systolic expulsion shortens. Vasomotor changes probably occur, but there is no dynamic evidence that they are reflected in the changing systolic and diastolic pressures. Effective venous pressures fall slightly, not through reduced venous return but due to greater minute output by the faster heart.

During true anoxia, which begins when oxygen of the inspired air is progressively decreased below 12 per cent, the heart responds with greater stroke volumes and with further increase in velocity of ejection. The economy of effort is enhanced. Experiments on dogs with "controlled circulation," i.e., in animals whose heart rate, arterial diastolic and venous pressures, as well as alveolar carbon dioxide are kept constant, have demonstrated that the increased systolic discharge is accompanied by increase in diastolic size, independently of changes in venous pressure. Such compensatory reactions probably could not occur without the unquestioned dilatation of coronary vessels.

Further decline of oxygen in the inspired air to 7 or 6 per cent, corresponding to arterial oxygen saturations between 50 and 35 per cent and to altitudes up to 30,000 ft., leads to a circulatory crisis. Arterial pressures decline abruptly; pulse pressure is reduced; systolic discharge decreases; venous pressure rises tremendously; and various types of conduction and rhythm disturbances may occur. No evidence exists that peripheral vasomotor failure is concerned. The circulatory crisis is essentially an acute congestive heart failure due to the depressant effect of anoxia on the myocardium. It probably supervenes when the increasing coronary flow can no longer keep pace with the rapidly diminishing tension of oxygen in the blood.

AUTHOR.

Dressler, W.: Studies in Physical Diagnosis of the Heart. I. Percussion. Brooklyn Hosp. J. **3:** 196, 1941.

Percussion is a useful source of clinical information, provided that the method is simplified and subjective error reduced. Attempts to determine the position of the cardiac borders are futile and should be abandoned. This applies also to the distinction of absolute and relative dullness. Only marked dullness closely approaching flatness should be evaluated in the diagnosis of cardiac enlargement.

Certain abnormal areas of marked dullness signify enlargement of distinct portions of the heart. The normal area of marked dullness in adults extends from the left margin of the sternum to about 0.5 cm. inside the left midclavicular line,

and upward to the fourth rib. Craniad expansion of this dullness into the third left interspace characterizes dilatation of the pulmonary conus. Expansion of the cardiac dullness toward the lower half of the sternum signifies dilatation of the inflow tract of the right ventricle. Marked dullness to the right of the sternum in the fourth and fifth interspaces indicates dilatation of the right auricle.

Percussion of the sternum is particularly useful inasmuch as it may yield information about enlargement of the right ventricle earlier and more distinctly than it is shown by radiologic examination. Marked and extensive dullness over the sternum is also an important sign of pericardial effusion. As far as enlargement of the left ventricle is concerned percussion yields less reliable results than palpation of the apex beat and roentgen-ray study.

AUTHOR.

Huber, J. F.: The Arterial Network Supplying the Dorsum of the Foot. Anat. Rec. **80**: 373, 1941.

The "textbook picture" of the arterial supply of the dorsum of the foot in man was present in only 5.5 per cent of the 200 feet dissected.

An arterial network having an almost constant pattern was demonstrated in the dorsum of the foot which can serve as a basis for a practically universally applicable description of the arterial supply of this region when information is added as to how frequently each part of that network may be of significant size, such information having been given in the description of the individual vessels making up the network.

The anterior medial and anterior lateral malleolar arteries were found to branch more commonly from the dorsalis pedis artery rather than from the anterior tibial artery, as usually stated.

No one vessel was found which seemed to merit being called "the anterior perforating artery," but in its place five vessels are described for which the name "anterior communicating arteries" is suggested.

A branch of the anterior tibial artery about 5 cm. above the ankle joint, a previous description of which has not been found, was present as a vessel of significant size in about half of the feet, either contributing to, or being the principal source of, the perforating branch of the peroneal artery.

A comparison of the findings for negro and white cadavers seems to indicate that the negro more closely approximates the "textbook picture" as far as the blood supply of the dorsum of the foot is concerned.

Although little exact and detailed bilateral symmetry was found, there was a rather high degree of bilateral similarity.

AUTHOR.

Rutherford, R. B., Godfrey, E. W., and Griffith, J. Q., Jr.: Roentgenographic Observations Suggesting Difference Between Total and Circulating Blood Volume. Am. J. Physiol. **134**: 808, 1941.

After a strong vasoconstricting agent, pitressin, blood volume measured by a dye method is greatly reduced. We suggest that a considerable amount of blood may be trapped in areas of the peripheral circulation so that actively circulating blood volume may be much less than total blood volume. The blood still circulating shows relatively slight changes in hematocrit red cell volume or in plasma protein concentration. The presence of blood vessels in the extremities containing blood but without active circulation is shown by the following: (1) By microscopy, the skin capillaries contain red cells, but there is no flow. (2) Thorotrast introduced into the general circulation before the administration of pitressin remains in and outlines

the vessels of the extremities. (3) Blood cannot be secured by cutting a tail vein. (4) Thorotrast introduced into the general circulation after the injection of pitressin either does not enter into and outline the vessels of the extremities or does so tardily and to a lesser extent.

AUTHORS.

Cossio, P., Sabathie, L. G., and Berconsky, I.: Alterations of the S-T Segment and of the T Wave During or After Prolonged Crises of Paroxysmal Tachycardia. Rev. argent. de cardiol. **8**: 168, 1941.

In four relatively young patients during or after prolonged and repeated crises of paroxysmal tachycardia of supraventricular or ventricular origin, an opponent depression of the S-T segment and a negative T wave in Leads II and III (three cases) or in Leads I and II (one case) were observed. Autopsy of one case showed cardiac dilatation, integrity of the coronary vascular system, and absence of focal necrobiosis.

The electrocardiographic alterations described are thought to be due to the enlargement of the heart or to right ventricular strain. But whatever their cause it is a fact that they cannot always be imputed to a real coronary insufficiency. Five other observations have been found in the literature, one of them with necropsy, confirming this conclusion.

AUTHORS.

Bohning, A., Katz, L. N., Langendorf, R., and Blumenthal, B.: Intraventricular Block, Including So-Called Bundle Branch Block. Am. J. M. Sc. **202**: 671, 1941.

An analysis was made of the electrocardiograms of 176 persons with intraventricular block. They were classified according to the differences in pattern found in the limb and chest leads. The types were related to the probable delay in stimulation of the right and left ventricles, as suggested by the averages of the Q-E intervals (the time from the onset of QRS to the rise of the subclavian arterial pulse) in each group. Further, an analysis of some detail was made of the findings in twenty-five autopsied cases.

AUTHORS.

Prinzmetal, M.: Calculation of the Venous-Arterial Shunt in Congenital Heart Disease. J. Clin. Investigation **20**: 705, 1941.

A simple method has been described for determining the presence of a venous-arterial shunt in congenital heart disease, the magnitude of the shunt, and the true pulmonary circulation time in the presence of shunt.

AUTHOR.

Levine, H. B., and White, P. D.: What Sensible Living and Natural Recovery Can Do for a Cardiac Patient. New England J. Med. **225**: 101, 1941.

Seven patients with severe heart disease appeared to have unfavorable prognoses at the onset of their illness but through natural recovery or sensible living were able to lead long and useful lives. This emphasizes the statement that in acute heart disease "functional recovery may be so complete that the ultimate prognosis is good for many years after." It is not to be inferred, however, that one may dispense with medical attention. Furthermore, every person should seek medical counsel at the onset of symptoms, whether or not they are of cardiac origin.

AUTHORS.

Ernstene, A. C., and Schneider, R. W.: Angina Pectoris in Young Individuals With Aortic Insufficiency. Am. J. M. Sc. 202: 737, 1941.

Six cases of angina pectoris of decubitus in young persons who had rheumatic heart disease with pronounced aortic insufficiency have been reported. All of the patients experienced repeated nocturnal attacks, and it was of these seizures that they principally complained. In four of the six patients, attacks also were induced by exertion. Prominent vasomotor changes, such as flushing of the face, sweating, palpitation and throbbing of the vessels of the neck, accompanied the pain in five patients. The pain in each case was similar in location, quality, and radiation to that of the common form of angina pectoris and usually was relieved promptly by amyl nitrite or nitroglycerin. In none of the cases was the initial occurrence of angina pectoris precipitated by active rheumatic infection.

The average duration of life after the first attack of angina pectoris due to aortic regurgitation is greater than in patients who have angina pectoris due to coronary artery disease, but the prognosis is uncertain in the individual case because of a distinct liability to sudden death.

There is no medical measure that is effective in preventing the occurrence of the attacks in this form of angina pectoris. Various surgical measures have been employed and often with considerable benefit. Because of limited experience, however, no statement can be made as to the relative value of the different procedures.

The earlier literature concerning this form of angina pectoris has been reviewed briefly, and the pathogenesis of the attacks has been discussed.

AUTHORS.

Southworth, H.: Subacute Staphylococcus Endocarditis and Staphylococcus Bacteremia Without Endocarditis With a Report of the Favorable Effect of Sulfanilamide and Sulfathiazole in Two Cases. Ann. Int. Med. 14: 1180, 1941.

Two cases are reported of prolonged (over five months) staphylococcus bacteremia without an obvious focus of infection other than possibly an endocarditis. Six similar instances have been gathered from the literature.

In one case staphylococci were consistently present in the blood stream for seventeen months, and yet the patient maintained relatively good health.

In both cases the staphylococcus was antigenically a group C organism.

The difficulty of determining without autopsy whether or not there really is an endocarditis is stressed.

The favorable influence in one case of sulfanilamide and in another of sulfathiazole is described.

AUTHOR.

Geckeler, G. D.: Phonograph Records of Heart Sounds, Murmurs and Arrythmias. Am. J. M. Sc. 202: 685, 1941.

These records do well for self-teaching as well as for class work. The person listens with his stethoscope as the record is being played, simply holding the chest piece in his hand, with the bell or diaphragm exposed to the air. It is suggested that he sit comfortably in a quiet room and close his eyes (it always helps to blot out as many sensory stimuli as possible).

It is hoped that these records will fill the need of the family physician who has been away from a center for a number of years and who needs a "refresher." They are of value in undergraduate and post-graduate teaching, and they may have value to draft board examiners. Because of their inclusion of even rare auscultatory abnormalities, they are of use for reference.

AUTHOR.

Cahan, J. M.: Rheumatic Heart Disease in Families. Pennsylvania M. J. 44: 481, 1941.

This report is based on a study made by reviewing 1,627 private cardiac records of 1,517 children and 110 parents. These records showed that 629 patients had rheumatic heart disease at the time of examination or re-examination, some time between the years 1920 and 1940. In eleven of these the acquired lesion was combined with a congenital acyanotic heart condition. Families in which a parent and a child, or two siblings, were afflicted with rheumatic heart disease were selected for further study. A complete history relating to rheumatic symptoms was obtained of the entire family, and a careful examination was made of every available member of the family. So far, fifty-three families have been studied. The number of children in each of these families varied from one to ten and totaled 174, eighty-four boys and ninety girls. Two of the families had one child each; twenty-three families, two children each; ten families, three each; eight families, four each; two families, five each; five families, six each; two families, seven each; and one family, ten children. At the time of examination 128 of these children had rheumatic heart disease. Rheumatic heart lesions were also found in one of the eighteen grandchildren, in thirty-seven of the fifty-five parents examined, and in five of the seven grandparents examined. Altogether, 171 rheumatic heart cases were found among the 235 persons examined.

AUTHOR.

Ash, R.: The Evolution of Rheumatic Heart Disease in Childhood. Pennsylvania M. J. 44: 484, 1941.

The changes in physical signs of the heart that occurred in a group of 549 rheumatic children over an average period of nine years have been described. The majority of children destined to develop rheumatic heart disease had already done so in their initial illness. Moreover, the early months of the disease were relatively the most fatal. Methods designed to influence rheumatic infection must therefore be instituted upon the earliest appearance of any manifestation.

Recurrences were the predominant factor in the maintenance and in the fresh appearance of cardiac damage. In a small percentage of cases, however, signs of valvular disease made their appearance in the seeming absence of infection after a latent period of years.

Because of the cyclic nature of the disease, the tendency to recurrences, and the possibility of insidious development of valvular lesions, rheumatic patients should be kept under continuous medical supervision, with careful periodic examinations for signs of infection as well as signs of cardiac damage.

AUTHOR.

Berk, L. H.: Cardiovascular Syphilis. New York State J. Med. 41: 223, 1941.

Difficulties in diagnosing cardiovascular syphilis are outlined briefly, and the importance of the involvement of the coronary ostiums in prognosis is stressed.

Analysis is made of 172 cases. Included are twenty early and 117 advanced cases, thirty-five with necropsy. These comprise thirty-nine cases of uncomplicated aortitis, twenty-three cases of aneurysm, and 124 cases of aortic insufficiency.

An abnormal electrocardiogram with progressive serial changes is found to be (in the absence of acute myocardial infarction) strongly suggestive of syphilitic aortitis with probable coronary ostial stenosis.

It is demonstrated that a normal or borderline electrocardiogram in a syphilitic patient under 45 years of age may become positive after the exercise test is given, thus establishing the diagnosis of aortitis with probable coronary ostial stenosis.

The importance of the electrocardiographic study made with the exercise test is emphasized as the only safe means of establishing the diagnosis of latent coronary ostial stenosis.

Routine use of the electrocardiographic study and exercise test in early cases with a systematic follow-up in subsequent years is urged in order to discover cardiovascular syphilis at an earlier stage than has been possible heretofore.

AUTHOR.

Weinstein, J.: Public Health Aspects of Cardiovascular Syphilis in New York City. New York State J. Med. **41**: 234, 1941.

An analysis of the available morbidity and mortality statistics and a consideration of the economic aspects of cardiovascular syphilis in New York City show that this disease is an important public health problem.

From a practical public health point of view no conspicuous change has taken place in New York City in the reported deaths from aortic aneurysm during the past decade and a half. Apparently, syphilis in a number of persons has not been recognized early enough or properly treated in the past to avoid later complications in the circulatory system.

The outlook for cardiovascular syphilis in the future is full of promise, and treatment of syphilis in its earliest possible stage is continued intensively for an adequate period of time.

Past experience has taught us that aortic syphilis will develop in a certain number of persons despite energetic and prolonged treatment of early syphilis. In this respect more knowledge is wanted, and further efforts in the direction of research on syphilis treatment and its evaluation are indicated.

AUTHOR.

Ritchie, G.: Metastatic Tumors of the Myocardium. Am. J. Path. **17**: 483, 1941.

Sixteen cases of metastatic tumors of the myocardium are reported, with a tabulation of certain features and a brief discussion. Thirteen different types of primary tumors were represented, and there was considerable variation as to route of metastasis and mode of growth within the muscle. In no case had a clinical diagnosis of cardiac invasion been made.

AUTHOR.

Wakerlin, G. E., and Johnson, C. A.: The Effect of Renin on Experimental Renal Hypertension in the Dog. J. A. M. A. **117**: 416, 1941.

Daily intramuscular injections of hog renin for four months produced striking reductions in the blood pressures of dogs with renal hypertension, whereas heat-inactivated hog renin and active dog renin were without effect.

No detected toxic manifestations resulted from the injections of renin or from the reductions in blood pressures. The sera of the dogs treated with hog renin, but not the sera of the dogs given injections of inactivated hog renin or dog renin, neutralized the acute pressor effect of renin (antirenin).

Daily intramuscular injections of hog renin into two normotensive dogs before and after constriction of the renal arteries prevented the development of hypertension. The mechanism of these therapeutic and prophylactic effects of hog renin in experimental renal hypertension in the dog is not clear. Most probably an immune (antihormone?) response to heterologous hog renin is involved.

AUTHORS.

Grimson, Keith S.: The Sympathetic Nervous System in Neurogenic and Renal Hypertension. Arch. Surg. 43: 284, 1941.

The author and co-workers have demonstrated previously that total sympathectomy prevents the pressor response to increased intracranial pressure. The experiments in this investigation have shown that total sympathectomy also prevents or abolishes for a time the elevation of blood pressure that follows section of the modulator nerves. Various types of localized sympathetic denervation have not prevented either of these types of neurogenic hypertension. It therefore seems likely that better results may be expected from total sympathectomy than from partial sympathectomy directed toward localized vascular beds, such as the splanchnic area.

NAIDE.

Corcoran, A. C., and Page, I. H.: Renal Blood Flow and Sympathectomy in Hypertension. Arch. Surg. 42: 1072, 1941.

Observations of preoperative and postoperative renal blood flow and filtration fractions in two cases of essential hypertension treated by extensive sympathectomy are reported. The operation did not increase renal blood flow or decrease the degree of efferent arteriolar constriction in either case. These observations are in accord with experimental data obtained from chronic experiments in animals and with other observations on the effect of renal denervation and sympathectomy in man.

It is concluded that the benefits of sympathectomy in cases of hypertension do not depend on improvement of renal circulation resulting from interruption of renal nerves. The suggestion is made that the decrease of arterial pressure which follows sympathectomy in hypertensive man is an expression of denervation of the reactive visceral splanchnic innervation, with resultant partial failure of venous return, most evident in the erect position. The decrease of venous return limits cardiac output and thus tends to decrease arterial pressure. It is further suggested that the decrease of arterial pressure is in itself an adequate explanation of the clinical improvement which may follow such an operation, since it may prevent the further spread of arteriolar lesions.

The probable relation of the renal vasopressor system to hypertension is reviewed, and it is noted that renal vasoconstriction in cases of hypertension is probably humoral rather than neurogenic in origin. The view is proposed that decreased arterial pressure occurring as a result of sympathectomy may arrest the progress of renal arteriolosclerosis in a hypertensive patient and that, since these arteriolar lesions may contribute to the release of renin and the activity of the renal vasopressor system, sympathectomy may thus interrupt for a time the progress of the disease.

AUTHORS.

Abeshouse, B. S.: Hypertension and Unilateral Renal Disease. Surgery 10: 147, 1941.

This is a review of the literature on hypertension and unilateral renal disease with a report of sixteen cases. In this group of patients, notwithstanding the fact that a definite causal relation between the hypertension and the unilateral renal disease could be established, neither an immediate nor a late reduction in arterial pressure occurred after nephrectomy. This may be explained on the basis that either the unilateral diseased kidney was not the sole etiological factor or the disease process had been present over a long period of time and had caused secondary arterial changes in its mate or elsewhere in the body which were responsible for the persistent hypertension.

It is important that an adequate period of time (at least one year) should elapse following operation before one attempts to evaluate the permanency and extent of the reduction in arterial blood pressure. In view of the uncertain end results and insufficient period of observation in the reported cases, there appears to be no justification for considering nephrectomy as a panacea for the cure of hypertension in every case of chronic unilateral disease of the kidney.

Every case of hypertension associated with unilateral renal disease should be subjected to a careful and complete urologic study in order to select those cases suitable for operation and to avoid the needless sacrifice of renal tissue in those patients who can ill afford to lose it.

It must be remembered that nephrectomy may be fatal in cases of hypertension of long duration or those whose clinical course is suggestive of the so-called "malignant hypertension."

NAIDE.

Brill, I. C., and Meissner, W. A.: The Role of Coronary Artery Disease in the Etiology of Auricular Fibrillation. Ann. Int. Med. **14**: 1341, 1941.

Data obtained from an examination of the records of 400 autopsied cases tend to suggest the following conclusions.

In the absence of congestive heart failure or acute coronary occlusion, coronary artery disease is not a cause of auricular fibrillation.

Congestive heart failure involving the left side of the heart, regardless of the underlying pathologic lesion, tends to favor the development of auricular fibrillation. It is suggested that stretching of the left auricle might be an important factor in this process.*

Coronary artery disease, although not a direct cause of auricular fibrillation, nevertheless may be concerned indirectly in the genesis of the arrhythmia by first inducing congestive failure. This mechanism is offered as a probable explanation for the frequent appearance of transient auricular fibrillation following an attack of acute coronary thrombosis, although this arrhythmia occurs very rarely in angina pectoris of coronary origin prior to the onset of congestive failure.

In a case already in congestive failure, the subsequent appearance of auricular fibrillation affords no additional information which might serve as an aid in determining the presence or the absence of coronary artery disease.

An analysis of the records of 100 cases of angina pectoris under active treatment confirms the observation already noted by many authors that auricular fibrillation is rare in angina pectoris of coronary origin, except in the presence of congestive failure.

AUTHORS.

Nelson, M. G.: Intimal Coronary Artery Haemorrhage as a Factor in the Causation of Coronary Occlusion. J. Path. & Bact. **53**: 105, 1941.

Changes in the vessel wall are considered to be of greater importance in the development of coronary occlusion than changes in the blood.

The most common predisposing disease is coronary atherosclerosis.

Many sinusoidal blood vessels are found in relation to intimal atheromatous plaques. These vessels occur in two situations, either deep in the intimal tissues close

*The effect of failure of the left ventricle upon the left auricle is often indicated by changes in the electrocardiogram relating to auricular activity, which are strikingly similar to those occurring in mitral stenosis. These changes which are believed to be due to hypertrophy and dilatation of the left auricle consist of a widened P wave of low voltage, usually bifid or flat-topped, They have been described recently by Wood and Selzer as a new and early sign of left ventricular failure.

to the media, or more superficially, near the endothelium. In the majority of cases they are surrounded by chronic inflammatory changes.

Hemorrhage from these sinusoids is a not uncommon finding in coronary atherosclerosis. Hemorrhages into the deeper zones of the intima heal by granulation tissue in which new capillaries are numerous. Such a process increases the fibrosis and the vascularity of the intima and predisposes it to further hemorrhage.

Superficial intimal hemorrhage is a most important factor in the etiology of coronary occlusion. It was present in eleven of seventeen patients examined, but, in nine of these, thrombotic occlusion of the lumen was also present.

The factors determining the intimal hemorrhage are probably weakening of the sinusoidal wall by toxic action and transient raised intraluminar pressure induced by exertion or emotion. In such cases superimposed intravascular thrombosis may be delayed until a subsequent period of bodily or mental rest.

AUTHOR.

Boyer, N. H., Leach, C. E., and White, P. D.: The Immediate Prognosis of Congestive Heart Failure. Ann. Int. Med. **14**: 2210, 1941.

The immediate prognosis in 748 patients with congestive heart failure has been studied and found, in general, to depend very little on the underlying type of heart disease, but, in varying degree, on the precipitating cause of failure, the patient's age, the degree of clinical cardiac enlargement, and the presence or absence of complications.

An additional analysis of the case histories of seventy-seven known hypertensive patients and ninety known nonhypertensive patients with coronary thrombosis revealed that a greater percentage of hypertensive patients will develop congestive heart failure than will the nonhypertensive, and consequently the prognosis is poorer for the former group of patients when coronary occlusion occurs. Once failure develops, however, the outcome is the same for those with or without antecedent hypertension.

AUTHORS.

Crafoord, C., and Jorpes, E.: Heparin as a Prophylactic Against Thrombosis. J. A. M. A. **116**: 2831, 1941.

In 325 cases involving postoperative treatment with heparin, symptoms of thromboembolic complications did not arise. In a control series of 1,111 similar cases such complications occurred in 9 per cent.

The patients selected were in both series over thirty-five years of age and submitted to operations on the gastrointestinal tract, the biliary system or the urinary passages or to major operations for hernia and varices.

Reference is made to another series of eighty-eight patients with gynecologic disorders operated on for myoma or prolapsus uteri without any thromboembolic complications. In the control series of 1,054 cases there were complications in 4 per cent.

The heparin used had a strength of about 70 per cent of the pure mucoitin trisulfuric acid. It was given as a 5 per cent sterile solution in intermittent intravenous injections four times a day. The ordinary dose was 50 plus 50 plus 50 plus 100 (or 75 plus 75 plus 75 plus 125) mg. daily, started four hours after the operation. The treatment was continued for five to ten days.

AUTHORS.

Ebert, R. V., and Stead, E. A., Jr.: Circulatory Failure in Acute Infections. J. Clin. Investigation **20**: 671, 1941.

Eight patients with circulatory failure produced by acute infection were studied. Five patients had lobar pneumonia; four of these had bacteremia. There was one case of streptococcal septicemia, one of staphylococcal septicemia, and one of bronchopneumonia without bacteremia. The circulatory failure was characterized by a decrease in peripheral blood flow and a fall in arterial pressure.

Measurements of the hematocrit level, the serum protein concentration, and the plasma volume showed no evidence of significant hemoconcentration or diminished blood volume.

The venous pressure determined before transfusion was normal.

Elevating the foot of the bed did not improve the circulation.

Transfusions of whole blood, or plasma, or the infusion of 10 per cent glucose in saline until the venous pressure rose did not produce any improvement in the circulation.

Blocking the ulnar nerve caused the ulnar side of the hand and the fourth and fifth fingers to become warmer than the other fingers. This showed that the vasoconstriction in the hand was neurogenic in origin.

The circulatory failure in these cases does not have the same mechanism as that of hemorrhage or traumatic shock, because the plasma volume is not decreased and transfusions are not beneficial. It is not caused by venous pooling, because filling the venous system does not improve the circulation.

The entire cardiovascular system appears to be damaged by the infection. The absence of congestion and the fact that the venous pressure is not increased may be explained by simultaneous injury to the heart and loss of venous tone.

Improvement in the circulation occurs only when the infection is brought under control. Therapy should therefore be directed toward overcoming the infection rather than attempting to treat the circulatory failure itself.

AUTHORS.

Cole, G. C.: The Conus Arteriosus and the Pulmonary Artery. Am. J. Roentgenol. **45**: 32, 1941.

An improved method of visualization of the pulmonic conus and the pulmonary artery, as well as the left hilum region, is described. That it has definite advantages over the standard methods of visualization is clearly demonstrated.

The method is based primarily upon a knowledge of the anatomic and histologic structures of the conus arteriosus and proximal portion of the pulmonary artery, as well as upon mechanical changes, namely, rotation of the conus on its horizontal axis so that its greatest length and depth will be horizontal to and traversed by the central rays, and also upon exaggeration of structures by bringing them farther away from the screen.

AUTHOR.

Mohs, F. E., Sevringhaus, E. L., and Schmidt, E. R.: Conservative Amputation of Gangrenous Parts by Chemosurgery. Ann. Surg. **114**: 274, 1941.

A method is described for chemically fixing gangrenous tissue to prepare it for conservative amputation. The technique consists of rendering the surface keratin permeable to zinc chloride by applying a keratolytic such as dichloracetic acid. Zinc chloride paste is then applied to the involved area in a layer 2 mm. thick, in order to fix the lesion to a level somewhat proximal to the limits of the visible gangrene. The material is held in place by a cotton dressing, and excessive drying is avoided by covering with a second layer of cotton, spread with vaseline.

After about twenty-four hours the gangrenous area (usually a toe) has been fixed and can be amputated.

The extraordinarily favorable healing after this procedure made possible successful results in over 60 per cent of sixty-six conservative amputations in a series of cases which was essentially unselected in regard to circulatory efficiency. There were no breakdowns of the scars once healing had occurred, and there were no operative deaths in this series. The method enables the conservative treatment of gangrene to be extended to a much larger group of patients than was previously possible.

NAIDE.

Allen, Frederick M.: Reduced Temperatures in Surgery. I. Surgery of Limbs. Am. J. Surg. 52: 225, 1941.

The author outlines a method of amputation of extremities of patients with vascular disease with the use of refrigeration. The reduction of temperature enables the surgeon to use a tourniquet to obtain a bloodless field. Also, the refrigeration induces anesthesia of the extremity so that all the harmful effects of the usual anesthetics are avoided. A cold environment is valuable in preventing infection, aiding in healing, minimizing thrombosis, and reducing aftershock.

NAIDE.

Taylor, N. B., and Waters, E. T.: Isinglass as a Transfusion Fluid in Hemorrhage. Canad. M. A. J. 44: 547, 1941.

Because of the difficulty involved in obtaining large quantities of blood or serum for the treatment of hemorrhage, the authors looked for a substitute which would meet the rigid requirements of a transfusion fluid. A 7 per cent solution of fish gelatin or isinglass in 0.9 per cent saline was found to fulfill the specifications of a transfusion fluid.

As prepared from the sounds (air bladders) of fish by the method described, isinglass is soluble in water or saline, is without toxicity, and can be readily sterilized by raising its temperature to 100° C. for five minutes. It forms a perfectly clear pale yellow solution.

Experiments are reported in which a 7 per cent solution of isinglass in saline was capable of restoring the blood pressure after it had been lowered by hemorrhage and of saving the lives of animals which, had no treatment been instituted, undoubtedly would have died. These animals made a complete and uneventful recovery.

NAIDE.

Wood, G. O., and Blalock, A.: Effects of Uncomplicated Hemoconcentration (Erythrocytosis). Arch. Surg. 42: 1019, 1941.

Marked degrees of hemoconcentration unaccompanied by significant alterations in the blood volume have been produced experimentally by the removal of whole blood and the reintroduction of the red blood corpuscles together with additional ones from compatible donors. Rather marked hemoconcentration produced in this manner is compatible with life in experiments of the duration recorded and does not usually result in significant alterations in the tissues except for vascular engorgement. Whereas both hemoconcentration and reduced blood volume exert deleterious effects in the presence of shock, it is concluded that it is the decrease in the blood volume with the resulting anoxia that is responsible for most of the damage to the tissues. It should be emphasized that these experiments are concerned not with

chronic erythrocytosis but with temporary elevations in concentration, such as may occur in association with shock.

AUTHORS.

Blalock, A., and Mason, M. F.: A Comparison of the Effects of Heat and Those of Cold in the Prevention and Treatment of Shock. Arch. Surg. 42: 1054, 1941.

The effects of causing rather marked elevations or depressions of the body temperature of animals in shock as a result of hemorrhage or trauma have been determined. Significant elevations of temperature decrease the chance of life and shorten the period of survival. The application of cold does not increase the chance of survival but is accompanied with a lengthening of the survival of an animal with a low blood pressure. Significant elevations of temperature cause more disastrous effects than do depressions of similar degree.

AUTHORS.

Ershler, I. L., and Blaisdell, I. H.: Massive Hematuria Following Use of Heparin in Cavernous Sinus Thrombosis. J. A. M. A. 905: 927, 1941.

The intravenous administration of heparin produces a significant prolongation of the coagulation time, which is, in fact, a hemorrhagic diathesis. Consequently there may be produced dangerous bleeding in vital areas of the body. A patient with cavernous sinus thrombosis, treated with sulfathiazole and heparin, presented profound renal bleeding from which there were no serious sequelae. Bleeding from cerebral, pulmonary, or coronary vessels might conceivably result in disaster.

NAIDE.

Rigdon, R. H., and Wilson, H.: Capillary Permeability and Inflammation in Rabbits Given Heparin. Arch. Surg. 43: 64, 1941.

Heparin as used in these experiments has no effect on capillary permeability, the macroscopic development of inflammation, or the localization of leucocytes in areas of inflammation.

The phagocytosis of staphylococci by polymorphonuclear leucocytes in vivo apparently is not affected by heparin.

AUTHORS.

Book Review

SURGERY OF THE HEART: By E. S. J. King, M.D., D.Sc., F.R.C.S. (Eng.), F.R.A.C.S., Major, A.A.M.C., Honorary Surgeon to Out-Patients, Royal Melbourne Hospital. Williams and Wilkins, Baltimore, 1941, 728 pages, 268 illustrations, $13.50.

This book was prepared as a dissertation for the Royal College of Surgeons, in 1938. It was granted the Jacksonian prize. I believe that many physicians would like to have it in their libraries. It contains an extensive review of the literature up to 1937. The book is a good reference work, and can be recommended to those surgeons who are exploring any of the fields which it covers.

A large part of the book is devoted to a discussion of nonsurgical topics. Undoubtedly this is done for the purpose of making the book approach completeness, because these discussions have little or no relationship to surgery. There is a chapter on developmental abnormalities of the heart. However, the only developmental abnormality that can be treated by operation, namely, patency of the ductus arteriosus, receives one paragraph of discussion, and the operation is not illustrated. The chapters on anatomy, physiology, and pathology appear to be well written, but I question the relationship of this material to surgery. For example, under the subject of histology one finds a discussion of the muscle fiber, transverse striations, the sarcomere, the form of the striations, intercalated discs, protoplasmic organoids and inclusions, the sarcolemma, the nucleus, and so on. The chapter on pathologic physiology is good. However, when we turn to the practical application of some of this information on pathologic physiology, there is something to be desired. Resuscitation of the heart is not presented as a practical problem. The author does not tell the surgeon precisely what to do if the ventricles should go into fibrillation during an operation on the heart.

In his chapter on electrocardiography the author has this to say: "There can be no doubt, especially recently, that many investigators have been trying to give to small changes a significance which they do not possess. Every study requires the most careful and critical control before it can be accepted." The chapter on the surgical approach to heart disease is good. The chapter on injuries to the heart is exceptionally good. The author discusses abscess of the heart, chronic myocarditis, rheumatic fever, tuberculosis of the myocardium, syphilis of the heart, actinomycosis of the myocardium, enlargement of the heart, decompression of the heart, displacements of the heart, vascular disease, calcification, tumors of the heart, parasitic diseases, hydatid disease, coronary occlusion, paravertebral injections, total thyroidectomy, aneurysm of the coronary arteries, and rupture of the coronary arteries. Valvular disease is discussed in reference to the possibility of operative treatment. Diseases of the pericardium embrace 141 pages.

The following quotation is from page 628: "Constrictive pericarditis must be distinguished from other (I) pericardial disease, and (II) from other conditions. (I) The confusion between various forms of pericarditis is demonstrated excellently in the literature. A brief consideration of the essential differences due to the site of the fibrosis, as described above (p. 602), however, indicates the differentiating features. Thus evidence of extra-pericardial adhesions to the chest wall is absent. Such adhesions may be present, but the density of the pericardium, limiting cardiac movement, prevents their becoming apparent clinically. Broadbent's sign therefore

is absent (Turk). The heart is much smaller than in mediastinopericarditis, valvular lesions are usually absent, and there is no history of rheumatism.'' This is an example of the confusion that exists in the literature, and the author has failed to clarify the subject.

The author makes a plea for opening the pericardium when the heart is enlarged. A quotation from page 642, on the restrictive action of the pericardium on the enlarged heart, is as follows: ''The study of this condition has been given impetus in recent years by the observations of Felix. He has emphasized the lack of adequate concomitant stretching of the pericardium in some cases of cardiac enlargement so that it is tightly stretched over the heart. Although his explanation of the symptoms—that there is a relative compression of the right ventricle—is not in accord with other observations on the physiological action of the heart, his observations are of the greatest importance. The treatment suggested—an incision in the pericardium—allows the heart to bulge and is followed by considerable relief of symptoms and signs. This improvement has been observed by the writer in several cases.

''Experimental work on animals, especially the racing greyhound, is of special significance in this regard. Some animals develop a marked diminution of cardiac reserve shown by enlargement of the heart and, after exercise, by cyanosis (most easily observed in the tongue), dyspnoea and an easily observed thrill over the apex beat. Such animals are unable to perform as well as formerly and indeed may collapse before finishing an ordinary course. They recover from the effect of exercise much more slowly than do normal dogs, often requiring two to three times as long. Wide incision of the pericardium, which is followed by bulging of the heart into the opening, is followed by very great improvement so that the animal is able once more to compete with its fellows. Such observations have been made by O'Shaughnessy and McCunn. The writer has been astonished on several occasions by the degree of improvement obtained.

''This experimental work has an important bearing on human cardiac disease and there appears to be a proportion of cases of cardiac decompensation, as the writer found, which are improved by the procedure. . . .''

It seems to me that the writer is using strong generalities in recommending this operation. I believe that the reader would like to have actual observations on patients concerning the results. If the author is correct, the reader would like to have a program of action, so that his patient with cardiac decompensation can be given the benefit of this operation. I believe that he would also like to have the experiments and their controls, so that he could arrive at his own conclusion concerning the subject. This operation has not become established, and a practical program of action in reference to these patients is not found in this book.

The book has much to recommend it. It seems to me that the author of a monograph on surgery of the heart must expect to encounter difficulties and pitfalls. The total experience in this field is not great. There are few surgeons who have done as many as fifty operations on the human heart. It can readily be understood that if the experiences are few, the conclusions can be expected to be indefinite and variable.

CLAUDE S. BECK.

In Memoriam

Stewart Ralph Roberts
1878-1941

Stewart Ralph Roberts, Professor of Clinical Medicine at Emory University, Atlanta, Georgia, died at his home on April 14, 1941. In 1938 he had an extensive cardiac infarction from which he made a very slow recovery, but, for the past two or three years, although physically incapacitated to a great extent, he was able to carry on part of his teaching in the medical school and a limited consulting practice.

He was born at Oxford, Georgia, near the campus of Emory College, on Oct. 2, 1878. He was the son of the Reverend J. W. Roberts and Clifford Rebecca Stewart. His father was a graduate and trustee of Emory College. His grandfather, Joseph S. Stewart, graduated from Emory College with second honor, and for several years was also a trustee of this institution. His great-grandfather Starr, in 1849, was one of the original contributors to the establishment of Emory College.

With such a heritage it is easily understood why, during his entire life, Stewart Roberts manifested a great interest and love for Emory College, and was always interested in every opportunity that afforded advancement or improvement for this school. This interest was not only of paramount consideration during his college days, but throughout his entire professional career, when much of his interest was transferred from the academic to the medical department.

In 1894 Dr. Roberts first entered Emory College at Oxford, Georgia. After two years of college work he decided to abandon this field of endeavor and to undertake the study of medicine. In 1896 he began the study of medicine at the Southern Medical College, which, in 1898, became the Atlanta College of Physicians and Surgeons, from which he graduated in 1900. After his graduation in medicine he became dissatisfied with his literary training, and, in the fall of 1900, he returned to Emory College and for two years devoted himself to further academic study, graduating in 1902 with the degree of B.S.

The following year he became Professor of Biology at his Alma Mater. Several years later he did postgraduate work at the University of Chicago and also at the Harvard Medical School. He taught biology at Emory College from 1902 until 1906. Resigning this professorship, he moved to Atlanta and became Professor of Physiology at the Atlanta School of Medicine, where he taught from 1906 until 1910. Shortly after

he assumed the professorship of Physiology, the Atlanta Medical College and the Atlanta College of Physicians and Surgeons combined to form the Medical Department of Emory University. During this period of reorganization Dr. Roberts became Professor of Clinical Medicine, a chair which he occupied with dignity and honor until his death.

STEWART RALPH ROBERTS

Many honors were conferred upon him by his colleagues. He was at one time President of the Fulton County Medical Society, the Southern Medical Association, Vice-President and member of the Board of Regents of the American College of Physicians, a diplomate of the American Board of Internal Medicine, Physician to Emory University Hospital, Consulting Physician to the Henry Grady Hospital, President of the American Heart Association, and Vice-President of the Medical Association of Georgia.

During the last World War he was a Lieutenant Colonel in the Medical Corps, in command of the Base Hospital of Camp Jackson, Columbia, South Carolina. In this particular capacity he rendered most distinguished service.

He was a member of the Kappa Alpha, Omicron Kappa Delta, Phi Beta Kappa, and Alpha Omega Alpha Societies.

His ability as a writer and as a speaker is well known. His many contributions to the advancement of medical science have been published in the leading medical journals of this country. His book on pellagra, published in 1912, was a very authoritative statement of our knowledge

of this disease at that time. Very few physicians have ever equalled or surpassed Dr. Roberts in his ability to speak authoritatively and convincingly before medical gatherings, and very few organizations have not had the privilege of hearing his voice.

For many years he had a great interest in cardiovascular diseases, and, during 1933 and 1934, while President of the American Heart Association, he was most helpful in the deliberations and counsel of this body.

He is survived by his wife, the former Miss Ruby Holbrook, and three sons. A host of friends and associates will miss his counsel, his advice, and his kind and generous philosophy.

JAMES E. PAULLIN.

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THE American Heart Association stands alone as the national organization devoted to educational work relating to diseases of the heart. Its Board of Directors is composed of twenty-seven physicians representing every portion of the country.

The Section for the Study of the Peripheral Circulation was organized in 1935 for the purpose of stimulating interest in investigation of all types of diseases of the blood and lymph vessels and of problems concerning circulation of blood and lymph. Any physician or investigator in good standing may become a member of the section after election to the American Heart Association and payment of dues to that organization.

To coordinate and distribute pertinent information, a central office is maintained, and from it issues an ever widening stream of books, pamphlets, charts, posters, films, and slides. These activities all concern the recognition, prevention or treatment of the leading cause of death in the United States, diseases of the heart. The AMERICAN HEART JOURNAL is under the editorial supervision of the Association.

The income from membership and donations provides the sole support of the Association. Lack of adequate funds seriously hampers more widespread educational and research work imperative at this time. Great progress has been made, but much remains to be done.

Annual membership is $5.00 a year and journal membership at $11.00 includes a year's subscription (January-December) to the AMERICAN HEART JOURNAL and annual membership in this Association. A cordial invitation to join in this crusade is extended to you.

The American Heart Association solicits your support to the end that it may continue more effectively the campaign to which it has devoted all its energy.

•*Executive Committee.*